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JUNE 1959

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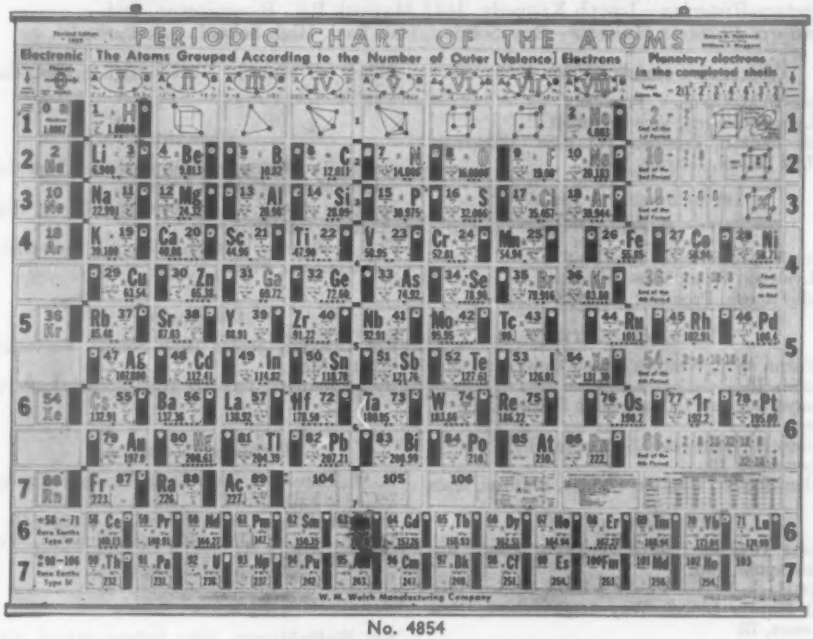
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SCHOOL SCIENCE AND MATHEMATICS

VOL. LIX JUNE, 1959 WHOLE NO. 521

How General Science Began

Hanor A. Webb

Professor of Science Education, Emeritus, George Peabody College for Teachers, Nashville, Tennessee

What analogy shall we select for the beginning and development of general science as a subject in our high schools?

Shall it be a *nova* in the heavens, existing dimly for aeons, bursting suddenly into view, then quickly fading into faintness? This is not accurate, for general science is not fading.

Shall we consider grains of wheat, found—if we believe the guide—in an Egyptian tomb, which after centuries of dryness sprout and grow when the nourishment of soil and water is supplied? We doubt the camel-driver's honesty, and the grains' antiquity; if we cannot trust an analogy, let us reject it.

Suppose we take a fragment of uranium ore, buried since our planet cooled, discovered by intelligent humans as a source of rays, then of heat, finally of power almost unlimited. This is true! This is exciting! It shall be our analogy of general science!

The present generation of young science teachers may consider general science as they do the automobile—"has it not existed always?" The germ of the ideas—of cars and courses—is indeed of venerable age. As a rule, however, both inventions and school subjects must wait until their times are ripe.

EARLIEST SCIENCE BOOKS

The special—as contrasted to the general—sciences are ancient indeed. An early text on *mathematics*, written by Ahmes of Egypt before 1700 B.C., is on papyrus in the British Museum. It was de-

ciphered in 1877. The first text in *physics* was written by Archimedes of Syracuse (287–212 B.C.), chiefly from his own experiments—including his famous bath. The first *chemistry* texts were by Aristotle of Athens (384–322 B.C.), the most noted of the ancient philosophers.

As the knowledge of the specialists in science grew, the desires of general scholars kept pace, we may be sure. It is an aspect of human interest; some like their information deep, others broad. The first book in general science that I have actually held in my hands is in the Library of Congress in Washington; *The Book of Natural Magick* by John Baptista Porta (1543–1617), his name and text translated from the Italian and published in English in 1616. Read the titles of his twenty chapters, and be convinced that his material is truly general science:

Chapters 1—Of the Cauſes of Wonderful Things; 2—of the generation of Animals; 3—of the production of New Plants; 4—of increaſing Household Stuff; 5—of changing Metals.

6—of counterfeiting Gold; 7—of the Wonders of the Load-Stone; 8—of ſtrange Cures; 9—of beautifying Women; 10—of Diſtillation.

11—of Perfuming; 12—of artificial Fires; 13—of tempering steel; 14—of Cookery; 15—of Fiſing, Fowling, Hunting, &c.

16—of inviſible Writing; 17—of ſtrange Glaſſes; 18—of ſtatick Experiments; 19—of pneumatick Experiments; 20—of the Chaos.

In certain chapters the "magick" is mingled with superstition, yet there is abundant science based on observation. From the chapter titles it is easy to guess where certain principles of biology, of chemistry, and of physics are presented.

The final chapter, "of the Chaos," is theological—almost a requirement of writers in those days. It comments on the danger that some impious or incautious experimenter, coached by Satan, could by some simple act trigger the destruction of God's Cosmos (the orderly universe) and bring on the Chaos. How close was Porta to a prophecy of the atomic bomb!

A few years later, in 1644, *Technica Curiosa* by Joannem Philippum was published. It is wholly in Latin. I copied its subtitle, and as an exercise for those science teachers who studied, and passed, their Latin courses, I present it as is appears.[1]

TECHNICA CURIOSA, Joannem Philippum. Libris XII comprehenſa, quibus varia Experimenta, variaque Technſmata, Pnevmatica, Hydravlica, Hydrotechnica, Mechanica, Graphica, Cyclometrica, Avto-

[1] For those who detoured Latin in their student days, here is a translation, in approximately the Latin order of words:

Curious Crafts, by John Philip. Twelve comprehensive chapters, in which various experiments, and various technical, pneumatic, hydraulic, hydrotechnical, mechanical, graphic, cyclometric, automatic, cabalistic, chronometric, and other arts strange unto miraculous, rare, curious, ingenious, and for the most part new and hitherto unheard of, for the erudite world's use, pleasure, and understanding proposed.

matica, Cabaliſtica, Chromometrica, aliaque Artis arcana ac miracula, rara, Curioſa, ingenioſa, magnamque partem nova & antehac inaudita, eruditi orbis utilitati, delectioni, diſceptionique proponuntur.

I own an eight-volume set of Oliver Goldsmith's *Animated Nature*, the Second Edition of 1779, published shortly after the author's death in 1774. Its 198 chapters of encyclopedic natural history are classic. New editions were published as late as 1925 by Yale University Press. Goldsmith was a writer, not a naturalist, hence he gives liberal credit to his contemporaries, Count de Buffon of France, Carl Linné of Sweden, and other authors of popular science of the Eighteenth Century.

Some two decades after Goldsmith, another author wrote almost as entertainingly. I have four volumes by George Adams, *Lectures on Natural and Experimental Philosophy*, London, 1794. His subtitle reads: "Describing in a familiar and easy manner the Principal Phenomena of nature, and shewing that they all co-operate in displaying the Goodness, Wisdom, and Power of God."

I have, in my collection of century-old general science books, these volumes—domestic and imported—and a number of others:

Thomas Webster, *Elements of Science and Art*, two volumes, London, 1822.

Alexander von Humboldt, *Cosmos: Physical Description of the Universe*, two volumes, London, 1849.

W. and R. Chambers, *Introduction to the Sciences*, Edinburgh, 1851.

Worthington Hooker, *Child's Book of Nature*, three volumes, New York, 1857.

J. Dorman Steele, *Fourteen Weeks in Astronomy; . . . in Botany; . . . in Chemistry; . . . in Geology; . . . in Natural Philosophy; . . . in Physics; . . . in Physiology; . . . in Zoology;* New York, 1872. Steele was a master in popular science writing, and may have made a fortune from his unique idea of the "Fourteen Weeks."

After the turn of the Twentieth Century, the books came rapidly. A count in the *U. S. Catalog of Books in Print, 1912*, indicates 139 titles apparently suitable for the interest and instruction of young folks in science. Many of these were in sets of two or more volumes. These were "trade books" for general reading rather than textbooks; general science was not yet a subject taught in the schools. It is true that such books were used by many teachers informally in classes; this writer was one of them in 1908.

The Trail-Blazing Texts

In 1911 P. E. Rowell's *Introduction to Science* (Macmillan, 75¢) appeared; it was an outline of topics rather than a text. Then in April, 1912, Bertha M. Clark's *General Science* was published, 363 pages,

with illustrations (American Book Co., 80¢), and an accompanying laboratory manual (40¢). This was the first real text in general science. After it came the deluge!

These are the trail-blazing authors of texts in general science: 1912—Bertha M. Clark, W. F. Cooley; 1913—P. E. Rowell (for fifth grade), W. A. Whitton; 1914—O. W. Caldwell and W. L. Eikenberry, H. W. Snyder; 1915—John C. Hessler, C. A. Pease. By the time Webb[2] began his pioneer study of the content of general science textbooks in 1917, eighteen of them contended for the opportunity to serve in the nation's high schools. The flood has never abated!

The ground had been well prepared for the use of these texts.

Committees and Controversies

At the meeting of the Central Association of Science and Mathematics Teachers in November, 1912, a committee on general science was appointed. Dr. Otis W. Caldwell of the University of Chicago was Chairman, and he reported at the November, 1913, meeting.[3]

The National Education Association appointed a committee, in 1912, that reported in March, 1913.[4] It had twelve members, "one for each of the twelve sciences taught in the high schools." The Chairman was William Orr, Deputy State Commissioner of Education, Boston, Mass. In addition to these reports, many articles appeared, chiefly in School Science and Mathematics, debating general science with vigor, sometimes with acrimony.

Selections from these published comments will show the nature of the discussions, better termed "controversy."

Dr. Caldwell's Committee: "As the various sciences have become differentiated and developed, most of them have been introduced into the high school curriculum in one or more parts of the country. Each science has merit, else it would not stand as a science. . . . Often eight different science subjects, and sometimes even twelve, are found in the high schools of a single state.

"These numerous sciences are contending with one another for a place in the high school, instead of presenting a demonstration of the efficiency of unified science . . . a need apparent to anyone who has studied the schools first hand.

"What should science do for high school pupils? It . . . should give knowledge of the world of nature, . . . more purposeful activity, . . . future occupations, . . . solving own problems, . . . enjoyment of life. The truths of science are the truths of life.

"First year science in the high school should be organized upon a

[2] Hanor A. Webb, *A Quantitative Analysis of General Science Texts, Part I. Contributions to Education Number Four*, George Peabody College for Teachers, 1921.

[3] This report is published in School Science and Mathematics, 14: 166–168 (1914).

[4] This report is in the U. S. Bureau of Education Bulletin 1913, No. 41, pages 28–31.

broad basis, including the fundamental principles of the various sciences, and using materials from all.

"Physiology and hygiene should be combined with physical education.

"In the second year emphasis should be on the biological sciences and their applications.

"The third and fourth years need diverging interests . . . physical and chemical science . . . domestic science, agricultural science, electives.

"The important thing is not to have each science represented in the high school course, but to include those phases of science which give the best education and open the widest opportunity."

Commissioner Orr's committee also recommended "introductory science" for the first year of high school, followed by physics in the second year, chemistry in the third, geography and/or biology in the fourth year.

In closing his report, Dr. Caldwell admitted that the committee members were not unanimous in accepting all of its statements, but that "further discussion, verbally and in the pages of SCHOOL SCIENCE AND MATHEMATICS is invited."

The discussion ensued!

DISPOSSESSED—PHYSICAL GEOGRAPHY

The high-school curriculum was full. Hence the introduction of general science would have to replace some established subject. Logically, it should replace another science. That science was there, and its proponents and instructors soon found it necessary to battle for their interests. Physical geography (later called physiography, still later earth science) had become established, through interest and excellent texts, as the first-year science in countless high schools So the controversy from 1912 on was chiefly between the groups favoring physical geography, and the sponors of "the interloper," general science.

It is impossible to quote the thrusts and counter-thrusts delivered verbally in small groups and at meetings. We can select arguments from the voluminous published articles, however, and show the course of the struggle of physical geography to save its life, and general science to gain its opportunity. Possibly Dr. H. W. Fairbanks, of the University of California, started the argument in 1910 with a two-pronged article *for* physical geography and *against* general science.[5] High spots of his comments were these:

"Physical geography is more adapted to immature minds . . . re-

[5] H. W. Fairbanks, "Physical Geography versus General Science," SCHOOL SCIENCE AND MATHEMATICS, 10: 761–772 (1910).

quires outdoor observation . . . all phenomena are primarily geographic, i.e., they take place somewhere . . . geography is vitalized; science is cold, abstract, impersonal.

"General science is sure to be poorly taught . . . has no harmony or unity . . . no one man in the University of California is capable of giving an all-round science course; could we expect to find such men in high school?"

He made numerous other statements in a similar spirit, and summarized in part: "After a long and careful analysis, it seems to me that the proposed course in general science for the first year of the high school is fundamentally a backward step. It is with the hope of discouraging this movement, and saving the high schools years of groping in the darkness of this general science notion, that I plead the advantages, from every standpoint, of physical geography. General science is but the dead skeleton of physical geography."

These presumptuous comments were soon answered with vigor. Dr. C. R. Mann of the University of Chicago wrote:[6]

"Fairbanks' paper proves, if it proves anything, that physical geography is as ill-fitted as it could possibly be for the purpose, and that only general science can ever satisfactorily meet the present demand. . . . The real battle is between a vital, concrete, significant, worth-while study of science . . . and the formal, abstract, coldly intellectual system of science whose teaching is now attempted in the schools."

Then Percy E. Rowell[7] of the Gardena Agricultural High School, California, showed righteous indigation as he wrote:

" . . . An article attacking general science as a first-year science, on account of its fallacious arguments, and because it showed an apparent lack of knowledge concerning general science, requires a reply. . . . General science includes physical geography, but is not limited to it. . . . Physical geography is actually a highly specialized science. . . . There are countless matters of everyday experience, none of which can by any stretch of an elastic imagination be made a part of a course in physical geography. . . . General science does not require teachers fully informed in all the sciences, but requires teachers who are broad-minded, and who take a delight in stimulating scientific imagination and ambition."

Let us match later viewpoints published in 1915. Against general science were the comments of John M. Coulter of the University of Chicago:[8]

[6] C. R. Mann, "Physical Geography versus General Science," School Science and Mathematics, 11: 17–19 (1911).

[7] Percy E. Rowell, "General Science versus Physical Geography," School Science and Mathematics, 11: 116–121 (1911).

[8] John M. Coulter, "The Mission of Science in Education," *School Review*, 23: 1–8 (1915).

"I can not agree with the method [of general science]. It is a substitute of the encyclopedic for the educative. [As an analogy] almost all the living languages are represented in Chicago's population, yet it would hardly seem rational to teach a child all the foreign languages at once, by picking out the commonest words and phrases of each."

But in the very next article, Fred D. Barber of the Illinois State Normal University[9] insisted that "much of the material which has has thus far (1915) appeared in texts called general science consists of clippings from the special sciences. . . . If general science is to be of educational value it must consist of well organized units of instruction, . . . fundamentally of practical or applied science, instead of units of theoretical science. . . . A course in general science, properly conceived, has eductional value of the highest order."

Later that year another pair of opposing viewpoints were expressed. John G. Coulter of the Illinois State Normal University[10] insisted that "it is better to study one subject as well as possible during the whole year, than to study two or more superficially during the same time. . . . The 'general' idea has run away with them entirely. . . . There is greed to include the universe, and to cover it in 150 hours. Possibly they confuse the youngster's mental palate with his mental gastric juice."

In concise rebuttal Dr. Otis W. Caldwell of the University of Chicago wrote:[11]

"The accusation that general science is encyclopedic is true in the sense that it attempts to include a measure of the scientific information which seems to be appealing and worthwhile to young learners."

Not all of the writers of articles expressed mere opinions on the matter; investigations were also reported. Some early ones seemed unfavorable to general science. E. E. Lewis of the State University of Iowa[12] stated the claims in favor of general science, with rebuttal according to his interpretations of a testing program:

Statement: General science teaches the pupil how to study a science, and how to think in scientific terms. *Answer:* Special courses in science will do this as well.

Statement: General science prepares for the study of physics and other sciences; it is an easy and interesting approach to special science. *Answer:* Elementary rather than general science would do this even better.

Statement: General science develops an inquiring spirit. *Answer:* All subjects should do this.

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[9] Fred D. Barber "The Present Status and Real Meaning of General Science," *School Review*, 23: 9–24 (1915).

[10] John G. Coulter, "Proposed Status of Science Instruction in the Junior-Senior High School Organization," *Educational Administration and Supervision*, 1: 639–645 (1915).

[11] Otis W. Caldwell, "General Science or Special Science," *School Review*, 23: 134–135 (1915).

[12] E. E. Lewis, "General Science in Iowa High Schools," *School Review*, 24: 426–435 (1916).

Statement: General science gives a summary of the fundamentals of science; it gives children scientific information which they crave. *Answer:* Good if true.

Statement: General science helps us bridge the gap between the work in the eighth and in the ninth grades. *Answer:* Not proved.

Statement: General science prevents many failures in the later specialized sciences. *Answer:* Not proved.

Statement: General science gives pupils who did not go on some idea of the field of science. *Answer:* Yes, valuable for this.

As expected, favorable results of other experiments were soon published.

Advice from Headquarters

Then came an authoritative declaration on the entire matter. The National Education Association's Committee on the Reorganization of Secondary Education, beginning about 1912, had reviewed the studies and writings of sixteen special committees, one on each of the high school subjects. Publication of their reports had begun with a Bureau of Education bulletin (1915, No. 23) on "The Teaching of Community Civics." The tenth of such bulletins appeared in 1920 as No. 26, "Reorganization of Science in Secondary Schools." Dr. Otis W. Caldwell, Chairman of the Science Committee, had selected forty-six science teachers to serve with him. These combined earnestness and experience. Each high school science, and supervisory duties, was represented by several of these collaborators. It was the privilege of this writer to be one of them, and to prepare a modest portion of the manuscript.

This bulletin[13] of 62 pages should be available in public and educational libraries. It is quite detailed in its recommendations for good teaching in the special sciences, and is responsible for many present methods of instruction in today's science classrooms. It had much to do with the development of laboratory work, from zero to present adequacy in many high schools.

The major value of this bulletin lay in the establishment of a firm sequence of the high-school sciences, that is almost universally observed throughout our nation to the present time. One might say that the place of the sciences in the high school became crystallized. Four practical sequences were outlined: A, for the junior-senior high schools; B, for large (500 or more students) four-year high schools with adequate staff and equipment; C, four-year high schools of medium size (200–500 students); D, small high schools (less than 200

[13] "Reorganization of Science in Secondary Schools," Bulletin 1920, No. 26, U. S. Bureau of Education.

students) with meager facilities.

In each of these high school types, general science including hygiene was assigned to the first year. The second year's science was biology in each recommendation. In the third and fourth years the offerings of physics, chemistry, and certain other practical sciences were listed, to be offered under various circumstances according to the size of the school, and emphasis desired in the community on the home, the farm, and industries. In all of these the formal science lecture, and highly quantitative laboratory assignments, were ruled out as inappropriate.

I have re-read this bulletin of 1920, and in my judgment its philosophies, its techniques, its major and even certain of its minor suggestions, are by no means obsolete after the passing of nearly four decades.

The Unconvinced

Did this official bulletin end the arguments over general science as the proper study for the first year of high school? Is *any* controversy every settled forever? In 1924 Mrs. Viva D. Martin of the Arsenal Technical High School, Indianapolis,[14] reported that "the course in civics is regarded as more profitable than general science [since it gives] a broad view of life, including the relation of science to it, and therefore is more valuable to the student than the limited phase showing the relation of science alone to life as presented by general science. . . . Thus general science was weighed in the balance, and found wanting."

Truly, this was the first time—perhaps the only time—that general science was discontinued because it was *too narrow!*

Then, in 1925, the eminent Dr. Robert A. Millikan of the California Institute of Technology,[15] giving advice to high school science teachers, wrote:

" . . . Again, I was intimately associated with the initiation of the general science movement—for which I hope God may some time forgive me!"

The genius of Dr. Milikan in scientific research prompts us to forgive him, too.

I have recounted—superficially, I admit—the events of that decade in which general science became established in the high schools of our nation. This not the end of the story, of course. General science has been tried now for nearly half a century. Its texts have improved

[14] Viva D. Martin, "General Science Weighed in the Balance," School Science and Mathematics, 24: 156–158 (1924).

[15] Robert A. Millikan, "The Problem of Science Teaching in the Secondary Schools," School Science and Mathematics, 25: 966–975 (1925).

amazingly, its enrichment material[16] has become abundant, its teachers well trained and dedicated to their subject.

Will you risk a prophecy that general science will continue to be the introductory science subject in high school, with continuous improvement in selection of its topics and effectiveness of its instruction even up to a century—to 2012, and after? If you believe in the analogy of atomic energy—long dormant, rapidly developed, universally serving the interests of our nation, you will consider the prophecy less of a risk than a certainty.

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[16] Such as *Current Science and Aviation*, American Education Press Publications, Columbus 16, Ohio. This weekly classroom newspaper has been published since January, 1927.

Tomorrow's Scientists, recently established by the National Science Teachers Association, National Education Association, Washington 6, D. C., is issued eight times a year.

1959 CASMT CONVENTION

The 1959 annual meeting of the Central Association of Science and Mathematics Teachers will be held at the Congress Hotel in Chicago, Illinois, November 26–28. The theme of the meeting is "New Science and New Mathematics for a New Era." Outstanding speakers have been invited for the general sessions. Dr. A. S. Householder of Oak Ridge National Laboratory has accepted the invitation to speak at the general session on Friday morning.

As at the two previous meetings, there will be tours, on Friday afternoon, to places of interest. There will be also on Friday afternoon, three interesting panels on "Modern Curriculum Problems." One panel will be devoted to Biological Sciences, one to Physical Sciences, and one to Mathematics. As panelists there will be a representative on each panel from each of the four instructional areas: elementary school, junior high school, senior high school, and junior college. After the general session on Friday evening, there will be an informal reception where old friends can be seen and new friends can be met.

The general session on Saturday morning introduces something entirely new to the CASMT program. The membershlp of the Association is being invited (consider this statement as your personal invitation) to submit titles for short papers to be presented. A strict time allotment of five to ten minutes will be given to those selected for presentation. Secretary Joe Kennedy will act as chairman of this general session. If you have an idea for the improvement of the teaching of science or mathematics which you would like to present on such a program write to Joe Kennedy, 1612 Matlock Road, Bloomington, Indiana. Tell him what your idea is and give him an outline of the suggested pattern of presentation.

The section meetings will follow immediately after this general session. The sectional chairmen are at work preparing interesting and challenging programs for you.

Let us all combine our efforts to make this annual meeting one of the best sessions of CASMT on record!

F. Lynwood Wren, *Chairman*

MATHEMATICS WORKSHOP

Twelfth Annual Workshop for Mathematics Teachers, to be held at Indiana University June 15–27, 2½ semester hours of graduate credit, for information write Philip Peak, School of Education, Director.

A Guide for Judging Arithmetics

In the March issue of SCHOOL SCIENCE AND MATHEMATICS there appeared a set of Criteria for Evaluating Elementary Science Books. As a companion to this article, and as another contribution to the "Elementary Science and Mathematics" feature now appearing in each issue, the following guide for evaluating elementary arithmetic books is presented. This guide is reproduced by permission of Ginn and Company, Statler Building, Boston, Massachusetts.

This scoring instrument was designed for country-wide use and has thus been made comprehensive. In specific situations, those using this list may want to eliminate some of the items in accord with the point of view regarding arithmetic in their system.

It is strongly urged that those responsible for making the selection give thorough and objective consideration to the items that are retained on their score card. The task of selecting an arithmetic series that will directly influence the lives of many children is an important responsibility, and each point should be given its deserved consideration.

This rating sheet permits evaluation of each item as Outstanding, Good, of Unsatisfactory. The spaces provided for further comments allow for important notations that need to be kept in mind. No attempt has been made to assign quantitative values to each of the points. Sensible qualitative judgments regarding the entire analysis will provide a better selection for your program than will a totality of points.

	Outstanding	Good	Unsatisfactory
I. AUTHORSHIP OF THE SERIES			
A. Have the authors been outstanding leaders in the learning and teaching of arithmetic?			
B. Do they understand how children learn and the needs and interests of children?			
C. Have they written successful arithmetic materials for children?			
Comments regarding authors:			
II. CONTENT			
A. Is there satisfactory development of concepts, generalizations, and relationships? (Have they been carefully selected? Properly graded? Is presentation meaningful—from concrete to abstract?)			
B. Are number-system ideas wisely used? (Is provision made for understanding small and large numbers, for discovery of computational processes, etc.?)			

	Outstanding	Good	Unsatisfactory
C. Are number-system ideas for the series finally brought together in a summarizing discussion?			
D. Is there systematic use of earlier-taught ideas in developing later ones? (e.g. Is the relation between factors and their product applied in problems and examples in multiplication and division with fractions, decimals, and per cents?)			
E. Is special attention given to such points of difficulty as zeros in quotients?			
F. Does the fraction development assure that pupils sense the size of the part when they note the number in the denominator?			
G. Are the several meanings of a fraction adequately presented?			
H. Is the very meaningful common-denominator method for dividing with fractions taught before the inversion method?			
I. Has systematically planned work with money numbers preceded decimal work as such?			
J. Have fractions and decimals been so taught that per cent work becomes only a minor variation?			
K. Is there thorough teaching of measurement including informal measurement units, approximation, and precision?			
L. Have ways of thinking to be used in mental computation been skillfully developed?			
M. Is the work with tables, graphs, and scale drawings systematic and practical?			
N. Is the introductory work for algebra and geometry well planned?			
O. Have business practices been introduced in situations that are understandable to pupils?			
Comments regarding content:			
III. The Problem-Solving Program			
A. Are the meanings of the processes systematically emphasized as the basis for solving problems?			
B. Is skill in reading problems developed? (Are pupils taught to recognize tricky words? To write problem questions? To restate problems?)			
C. Are sets of problems usually organized around interesting and realistic social situations?			
D. Are pictures, diagrams, graphs, and tables functionally used in solving problems?			
Comments regarding the problem-solving program:			
IV. Method of Presentation			
A. Is consistent development through concrete, semi-concrete, and abstract experiences provided in pre-book, book, and post-book suggestions?			
B. Are new ideas frcquently introduced through motivating social situations?			
C. Has provision been made for thorough reteaching at the beginning of each year and also at crucial points during the year?			
D. Is there oral guidance toward efficient thought processes?			
E. Do presentations move simply and directly in developing the main idea or skill on a given page?			
F. In any developmental lesson is there systematic progression from immature to mature methods of solution?			

	Outstanding	Good	Unsatisfactory
G. Is the practice program satisfactory? (Practice should follow development of understanding and efficient thought procedure. Immediate practice should be sufficient for first fixing of skill. Maintenance program should be well spaced and include practice on meanings as well as on skills. Ample provision should be made at each grade level for extra practice when needed.)			
H. Is learning thorough at time of presentation? (Is a major segment of the topic covered? Are a sufficient number of sequential pages used to assure real understanding and skill?)			
I. Is the presentation strengthened by frequent use of estimation and mental computation?			
J. Is there extensive use of charts and diagrams in the work with whole numbers, fractions, decimals, and per cents?			
K. Are pupils taught various checks on work?			
L. Does the program provide detailed help in caring for individual differences?			
Comments regarding methods of presentation:			
V. Testing Program			
A. What provision is there for inventory tests?			
B. Is there continuous evaluation through self-checking tests, periodic informal tests, and oral work?			
C. Is there a complete program of chapter tests (tests of meaning and information, computation tests, problem-solving tests, and diagnostic tests keyed to developmental and practice material)?			
D. Are additional tests available in the manual?			
Comments regarding testing program:			
VI. Other Aids to Learning			
A. Are major topics spread over more than one grade level to provide for developmental learning?			
B. Is there careful control of vocabulary, of sentence structure, and of paragraph length?			
C. Is color used functionally in pictures and diagrams and on the type page?			
D. Are variations in type and the page arrangements well planned for ease of use?			
E. Is there correlation with the content of other subject areas?			
F. Is there well-planned oral developmental work?			
G. Are the directions for exercises clear and complete?			
H. Is practice made interesting through variations in the text and helpful suggestions in the manual?			
I. Do the workbooks help to guide learning and provide ample writing space?			
Comments regarding aids to learning:			
VII. Other Aids to Teaching			
A. Are the ideas to be taught pinpointed? (Are there clue captions, carefully stated lesson objectives, specific background discussions, and so on?)			

	Outstanding	Good	Unsatisfactory
B. Are text pages made easily teachable? (Are oral and written work clearly designated? Are illustrated examples boxed? Are main points easily located, etc.?)			
C. Is the extra practice keyed to specific text pages and shown with answers in the corresponding manual lessons?			
D. Do the workbooks help evaluate the completeness of the pupils' understanding, as well as his level of skill?			
E. Are there teachers' editions of workbooks with answers?			
F. Do the teachers' manuals present a complete program for teaching arithmetic?			
1. A helpful general discussion.			
2. Overviews of the year's work and of the work in each chapter.			
3. Textbook pages reproduced with answers for all the work and not just for problems and abstract examples.			
4. Complete lesson plans including objectives, background discussion, pre-book lessons, book lessons, and sufficient extra suggestions for all pupils, slow learners, and more capable children.			
5. Further helps such as tests, bibliographies, lists of films and film strips, and suggestions for devices and games.			
G. Do the texts, workbooks, and manuals have carefully worked-out reference aids, such as indexes, tables of contents, and grade-placement charts?			
Comments regarding other aids to teaching:			
VIII. Physical Features			
A. Is the total effect of the art work, use of color, and general appearance of the page "inviting" to the child?			
B. Have the illustrations been carefully made? (Are they abundant? Are they artistic? Are pages open and easy to use, yet complete in their coverage?)			
C. Is the paper of acceptable quality? (Has it the proper degree of whiteness without glare? Is it heavy enough to prevent "show-through?")			
D. Is the cover attractive and the book well made and durable?			
Comments regarding physical features:			

NEW PAIN-KILLING DRUG OUTCLASSES MORPHINE

A new pain-killing drug that appears to be 10 times more powerful, less addicting and safer than morphine has been developed by scientists at the U. S. Public Health Service's National Institutes of Health.

The drug, labeled NIH 7519, is made from coal tar derivatives. It belongs to a new series of chemical compounds called benzomorphans.

NIH 7519 is reported to have pain-killing power at least 10 times that of morphine and 50 times greater than codeine. The drug has been used on more than 200 human patients suffering severe pain. Delivery room and post-operative pain are the specific targets that the scientists said the new drug affected.

A Soviet Scientist Speaks Out on Science Teaching in the Soviet Union*

Eunice S. Matthew

Assistant Professor of Education, Brooklyn College

During the Fall of 1958, Premier Nikita Khruschev proposed a major reform in the educational system of the Soviet Union, after declaring that the school had become too far divorced from life and that highly undesirable social tendencies were manifest in the recruitment of students for higher education. There was, Khruschev said, an evident despite for physical work and a desise on the part of parents occupying positions of influence, to enroll their children in the universities mainly so that their children would not be working in the factories. There was an urgent necessity, Mr. Khruschev concluded, to give every youngster experience in practical work either in a factory or on one of the state or collective farms, upon the completion of seven or eight years of schooling. It was conceded that those young people showing outstanding scientific aptitude should continue into higher education. These proposals have since been ratified by the Praesidium of the Central Committee of the Soviet Communist Party.

On October 17th, 1958, the Soviet newspaper, *Pravda*, published an article under the title, "A Look at Tomorrow—a few thoughts on some problems connected with the reform of secondary and higher education." The *Pravda*, which is the official organ of the Communist Party of the Soviet Union, may hardly be considered a forum of casual discussion. What appears in its columns as a suggestion today has a good chance of becoming an officially adopted policy tomorrow. Moreover, the author of the article, Professor Nicholas N. Semenov, occupies a prominent position in the scientific and academic circles of the Soviet Union.

Professor Semenov was granted the Nobel prize for physics in 1956—the first Russian to be awarded this honor. He designed some of the essential instruments for the Sputniks and is somewhat regarded as "The Father of the Sputnik." For over forty years, he has been working in the broad field of physics, including chemical physics, molecular physics, and electronics. Starting with the study of the propagation of flames, he has produced world-famous studies on chain reactions. He has been the recipient of the highest awards bestowed by the Soviet Union upon scientists: the Stalin Prize, four

* Editor's Note: According to the author, this article "is based upon a translation which . . . [she] requested of a U.N. language specialist . . . ." The author believes that "it conveys a dynamic and forward-looking view of science education in the USSR as expressed by one of their authorities and leaders in the science field."

The editor will be pleased to receive comments about this article and will publish those presenting viewpoints of special significance.

Orders of Lenin, and the Order of the Red Banner for Labor. Since 1932, he has been a member of the Soviet Academy of Sciences. In 1947, he was admitted to the Communist Party. At present he is a professor at the Moscow University and Director of the Institute of Chemical Physics of Moscow. He was one of the key members of the Soviet delegation to the International Conference of Experts on Atomic Explosions, held in Geneva during the summer of 1958.

In the article published in *Pravda*, Professor Semenov, after giving due praise to Premier Khruschev's reforms, undertakes to make some concrete recommendations regarding the kind of scientific training which he deems necessary in view of the long-term demands of his nation's economy. He seems to be registering warnings of danger in any program which interrupts the education of those children who possess the highly valued scientific talents.

I

Any reforms in the educational system should take into account not only the present requirements of the State, he says, but also and very importantly, what their society will look like and need in ten or fifteen years from now, that is, at the time when the children now attending school will be taking part in actual production. By way of forecast, Professor Semenov envisions increased volume and efficiency in Soviet production, with the substitution of machines for painful, heavy work. The industrial plant of the future will be highly efficient, completely mechanized and automated. Moreover, in keeping with the explosive progress of science, old industrial processes will be constantly yielding to improved and entirely new discoveries.

The key to survival in industry will be the quick introduction of new discoveries into production. By the very nature of the mechanization and automation, Professor Semenov warns, the highly productive plants of the future will lend themselves poorly to improvement and even less to change, unless provision is made for the close collaboration of research and production. Therefore, in the opinion of Professor Semenov, the industrial plant of the future will need to consist of two interacting units: the ***production*** plant, highly automatized, equipped with specialized machinery, apparatus, devices, even up to electric counters; and the ***huge plant laboratory*** with a design bureau endowed with the means to carry out research on the latest achievements of science, on new technological processes, and on experimental and industrial designs to be adopted by industry. Due to the rapid expansion of electrification and mechanization already achieved, agriculture in the Soviet Union will probably (but in the less immediate future), be affected by the same tendency as industry.

At any rate, it seems that a shift will occur in the relative numbers of factory engineers and research or design engineers. It is expected that the tendency will be definitely in favor of a constant increase in engineers who are competent in research and new designs. It will not be necessary for factory research laboratories to engage in abstract scientific work. This activity will continue to be carried out by governmental research institutes, sponsored by the ministries heading the key industries of the national economy. In constant contact with these institutes, factory research laboratories would have only to solve the specific problems dealing with the particular industry or just the particular industrial plant in which the laboratories are located.

II

What are the implications of this projected scheme for the training of future technicians and scientists? First of all, Professor Semenov emphasizes that the dual nature of industrial work in the future will require two different kinds of personnel. There will be the factory engineers who must have a thorough knowledge of the complicated installations of an automatized plant and who must be well acquainted with the various technological processes. They will also need to know the nature of raw materials, be acquainted with the economics of production, and possess organizational and management abilities. On the other hand, there will be the industrial research or laboratory engineers, who, while having a good understanding of technology, will need to be essentially scientists, particularly trained in research and experimentation. In all highly industrialized countries, Professor Semenov notes, there is increasing demand for research engineers. Automation is already reducing and, in ten to fifteen years from now, is bound to further reduce the ranks of factory technicians.

On the basis of this reasoning, Professor Semenov proposed a network of specialized institutions for higher education in science: (1) practical engineering colleges to prepare production engineers; (2) research laboratory schools for initial experimental studies by future industrial research engineers; and (3) higher research universities which will train top research scientists and designers of new technical processes.

To the practical engineering colleges, Professor Semenov gives short treatment. At this point he entirely accepts the ideas of Premier Nikita Khruschev regarding the desirability of early production experience for students. Each college of practical engineering would be attached to a particular industrial plant. The recruitment of the student body would take place essentially from among young workers

who have served in production for some two years, after completing the seventh or eighth grade. Each practical engineering college would concentrate upon a particular industry and the candidates selected for admission would be chosen from among those young workers who had served in the industrial specialty of the college. These practical engineering colleges would also be open to students graduating from the *technikums*, or vocational junior colleges. These students would have already completed their work experience stint in a particular industrial line; then too they would also have acquired advanced technical training in their *technikum*.

Research laboratory schools would be set up to deal with scientific specialties, for example, schools for laboratory physicians, laboratory chemists, laboratory biologists, laboratory specialists for counting machines, etc. Professor Semenov advocates that students for this type of school be recruited from among the most gifted graduates of the eighth grade, who have proved their interest and aptitude for science. The curriculum in this new type of school would extend over three years. Eighteen months would be devoted to general high school education and the other eighteen months would be spent in concentrated work in the specialized subject of the school. Considerable work would be done in laboratories. The instructors should be graduates of research universities, specializing in the training of research engineers. All instructors should be enabled to conduct some investigations, with which their students would be associated; and there would be a close working link with the nearest research university or institute. In fact, each laboratory school would be sponsored by one of these higher centers, concerned with the same specialty. In order to guarantee the selection of the most gifted students from all over the country, laboratory schools would be provided with boarding facilities so that shelter, food, and supervision would be provided, thus insuring the inclusion of children from the rurals and from poor families. Upon graduation, these students would staff the laboratories and design bureaus of the factories. They may, however, go on to the research universities specializing in the training of scientific specialists such as research engineers and designers of new technical processes.

Professor Semenov strongly urges the organization of special *research universities*. These institutions would have a six-year curriculum. During the first two or three years, teaching would be centered on the fundamental sciences: mathematics, physics, chemistry, and biology. These theoretical courses would be solidly grounded in experimentation and laboratory work. From the beginning, the student should be afforded an opportunity to start his own independent work. The last two or three years of training would be devoted to research and design.

Each student would have to learn how to apply in practice the fundamental theoretical knowledge imparted to him. He would have to become acquainted with creative methods. He would have to acquire patience, purposefulness, and mastery in the methodology of experimentation. He would have to be able to extract by himself, from scientific publications, the elements he will need. He should be able to conceive his own experimental equipment, establish theories, and give mathematical formulation to the results obtained. He should be able to do by himself the work necessary for his experiments, whether it require glass utensils, practical applications of mechanics, or radiotechniques. He should know how to operate and service his equipment and how to carry out minor repairs. His dissertation, leading to the diploma, would have to constitute an original contribution to science and give proof of his creative ability.

Upon graduation, the students from the research universities would see three main careers open to them. Most of them would become the leading personnel of factory laboratories and design bureaus. Some would pursue abstract scientific work in the central research institutes of the ministries. Still others would form the teaching staffs of the laboratory schools.

To a certain degree, this work is already performed in Soviet universities and higher technological institutes, Professor Semenov admits. However, he opines, "this sum of knowledge and experience can only be imparted in institutions specially conceived for the purpose." These research universities should be located in cities where they would be able to enjoy the close support of central research institutes and large factory laboratories. This will mean that, during their last two or three years of training and during the preparation of their dissertation, the students will be able to work both in the university and in a factory laboratory. During at least half of the total time of their training, they will be in intimate contact with workers, technicians, and engineers in the big industrial plants or with scientific specialists in research centers. This arrangement would insure a novel type of connection between education on the one hand, and scientific, technical, and productive work on the other hand.

How should the students be recruited for the research universities? On this point, Professor Semenov seems to be registering disagreement with Soviet Premier Khruschev's policy of requiring production work for all students at the end of seven or eight years of schooling. "In my opinion," he writes, "the students of these research universities should be recruited mainly from among boys and girls graduating from the seven or ten-year schools. Young age and the lack of interruption in studies constitute very important conditions for the development of scientific and creative ability in young people. This is the conclusion to which I have arrived on the basis of my experi-

ence of thirty years as scientific leader and director of a scientific institute and forty years as a professor." It is not intended, of course, that these research universities be closed to those students whose capacities for scientific research will appear at a later age, when they have already engaged in practical work in industrial plants, research laboratories, or design bureaus. As a matter of fact, this older group may well provide about twenty-five per cent of the number admitted to the research universities.

III

A most important point to Professor Semenov is that extreme care be devoted to the proper selection of students who are to pursue scientific studies. Those admitted to the higher institutions of specialized and scientific study must be youngsters who are keen to acquire scientific knowledge and who share a liking for experimentation and design. Moreover, the selection of students should touch every hamlet of the vast Soviet land.

Professor Semenov gives his interpretation of what scientific aptitude is and how it manifests itself. It is much more common, in his opinion, than the gift for the arts. However, with the possible exception of the gift for mathematics, it appears at a much later age. While talent for the arts may always be detected before age ten, the gift for the sciences can be detected only between the ages of twelve to sixteen. "However, at these ages, scientific aptitude appears irrepressively." Its first manifestations are that the adolescent becomes interested in all kinds of experiments and within the limits of his knowledge, he seeks to establish, on the basis of these experiments, an overall picture which may be naive but nevertheless constructive. This prompts the budding scientist to take up, outside of the school curriculum, the reading of scientific and technical books and magazines. "Among my contemporaries or among my students who have achieved scientific success, I know of no scientist who had not evidenced such activity at the age I indicate."

"It should not be thought that a gift for science or its absence divides people into totally separate categories. This is not true. The only true idea is that if one is to take up science, he must have, among other qualities, a certain orientation in this direction." Special talents do not exist in the fields of art and science alone. There are well marked gifts for language, for mechanics, for the ability to fly modern airplanes, etc. At a later age appears the rare and very valuable gift for organizational leadership. In every case, it is highly essential to select people to work in the field for which they are gifted. It is especially so in the present period of scientific development.

This gift for science has no direct connection with the amount of knowledge possessed. The latter factor depends on the quality of the school in which the youngster receives his education, on the degree of education of his parents, etc. However, when evaluated in terms of creative activity, the scientific gift is not dependent upon these circumstances. It appears as well in those who graduated from rural as from urban schools. "Primarily, it finds its expression in a passionate seeking of knowledge, in an active, creative curiosity about some branch of science or technique. If the school cooperates, this quality develops more completely."

Everything must be done, Professor Semenov says, to encourage those youngsters who manifest interest in science. The best way to develop independent, scientific activity among children is to spread and perfect the system of children's technical clubs, which already exist in some Soviet schools. "The clubs," he writes, "must be provided with the necessary equipment, with scientific materials, and scientific publications. They must be provided with all the space they need to enable children to carry out experiments. Interesting lectures must be arranged. The necessary budgetary credits must be opened for that purpose."

It is indispensable to publish new scientific magazines for the young and to increase the circulation of those which are in existence. "It is sad to see that such an excellent magazine as *The Young Technician* should have such a small circulation." New magazines such as *The Young Physicist*, *The Young Biologist*, and *The Young Chemist* will probably have to be created. Demonstration equipment and laboratories, especially in rural schools, will have to be improved. Demonstration and laboratory work must be made compulsory in connection with the teaching of physics and chemistry. In regional centers, Homes for the Young Technicians should be opened. Schools need to be sponsored by public organizations and industrial plants. These sponsors together with the regional Communist Youth Organizations and the school must pay attention to the achievements of the pupils, not only in their curriculum studies, but also in their independent technical and scientific activities.

Once this stimulation and guidance has been given, selection of the most gifted should be made from among the students in the last grade of the general school, chiefly after seven or eight years of schooling, for admission to the *laboratory schools*. The main responsibility for the selection should rest with the Faculty Council of the school, who will take into account the appraisal of the student's Technical Club and the various organizations sponsoring children with a scientific bent. "No notice should be taken of the position of

their parents or of the influence which they may attempt to wield." Similarly, at the point of "second degree selection," that is, upon finishing the laboratory school, care must be exercised to be certain of choosing the best students for entrance into higher research institutions. The determination should be made by the faculty after considering the judgments of the leading scientists from the research universities or institutes.

IV

Having thus outlined the measures which he suggests for "the concrete implementation of the new policies formulated by Soviet Premier Khruschev," Professor Semenov concludes with a numerical forecast. In his opinion, "the primary degree of selection" of scientifically gifted children, in the last grade of the seven-year school or the ten-year school, for admission to the new laboratory schools should comprise from five to eight percent of all the graduates of the lower school. The second degree of selection for admission into the research universities would be reduced to about two or three percent of all children who finish the school of basic general education. "This," he states, "seems to me to be quite a logical figure in consideration of the conditions which we can foresee for our economy in ten to twenty years from now."

OVER-POPULATION CALLED THREAT TO NATIONAL SURVIVAL

Only if the American people understand the nature of over-population can this threat to the nation's survival be eliminated, Dr. Chauncey D. Leake, president-elect of the American Association for the Advancement of Science, warned.

He urged the nation's scientists and leaders to take the people into their confidence on over-population and give the public knowledge on major social problems. Nine other major problems listed by Dr. Leake are:

1. Control of nuclear energy;
2. Water and air pollution;
3. Conservation of our natural resources and preservation of the inherent beauty of the earth;
4. Removal of the continuing threat of authoritarianism;
5. Preservation of the dignity of individual human beings;
6. Promotion of individual responsibility for self-sufficient old age;
7. Promotion of optimum physical and mental health;
8. Preservation of our comforts, conveniences and cleanliness, with equal opportunities for all in decent living; and
9. Understanding and controlling of our individual and group prejudices, fears, anxieties and ambitions, so that we can enjoy the good life possible for us.

These problems, Dr. Leake said, are amenable to a scientific approach. He suggested that they be handled in this general way:

"Top priority should be given to more support, sympathy, appreciation, and better social recognition for basic scientific research. Basic science is concerned with getting verifiable information about ourselves and our environment."

Resistance as a Function of Temperature

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The following experiment illustrates that, in most conductors, resistance increases with the temperature. This fact alone can be shown with a light bulb and a few meters. The following device, however, gives the student practice in applying basic techniques and knowledge which he has already learned.

As illustrated in figure 1, a pivoted meter stick is supported by a sample of wire about one meter long. Locate point 2 at twenty or twenty-five centimeters from the pivot point. Connections are made so that a current can be passed through the sample. Enough power must be available to bring the wire eventually to 1000 or 1200 degrees centigrade. A voltmeter and an ammeter are used to find the resistance in the wire. These could be eliminated and a wheatstone bridge could be used to determine this resistance.

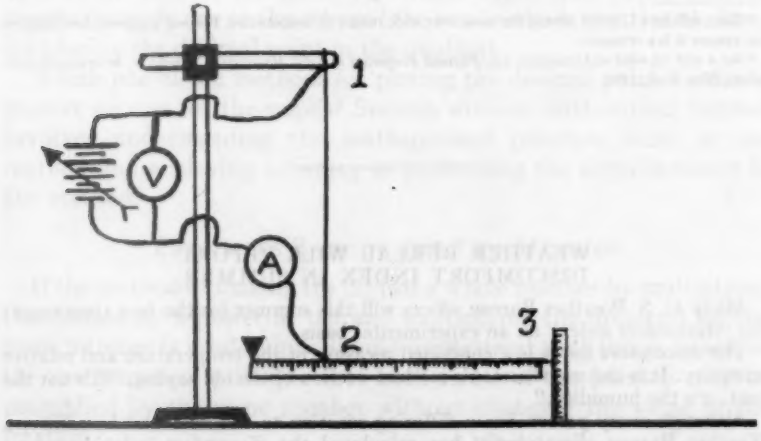

FIG. 1

The experiment consists of taking a series of ten or twelve readings of resistance at various temperatures. The temperature is computed by noting the change of length of the wire and using the relation:

$$\Delta T = \frac{\Delta L}{L_0 C}$$

where ΔL is the change of length, L_0 is the room temperature length and C is the coefficient of thermal linear expansion for each particular sample.[1] The ΔL is, of course, one-fourth or one-fifth of the change noted at point 3 in the figure. ΔT is the temperature of the wire minus the temperature of the room.

By plotting resistance, (better, resistivity), over absolute temperature, one can verify the interdependence. In most cases the resultant curve will extrapolate to the critical temperature, i.e., the temperature, near absolute zero, where the material becomes superconductive.[2]

The opportunities for good teaching offered by this experiment lie, not only in the careful performance, but also in the interpretation and discussion which should follow. Any or all of the following subjects could be mentioned by the teacher or reported on by individual students.

1. Thermistors and materials whose resistance goes *down* as the temperature goes up.
2. The Kammerlingh Onnes Ring Experiment when superconductivity was first exhibited in 1911.
3. The nature of the field of Solid State Physics—to *explain* such phenomena.

[1] The coefficient C is not always the same over wide ranges of temperature. For our purposes, however, we can assume it is a constant.

[2] See a text on solid state physics, e.g. *Physical Properties of Solid Materials*, C. Zwikker, Interscience publishers, New York, 1954.

WEATHER BUREAU WILL REPORT DISCOMFORT INDEX IN SUMMER

Many U. S. Weather Bureau offices will this summer for the first time report the "discomfort index" on an experimental basis.

The discomfort index is a combined measure of the temperature and relative humidity. It is the weatherman's modern version of the old saying, "It's not the heat, it's the humidity."

Although every person has a differing reaction to the heat and humidity, a Weather Bureau climatologist has calculated the discomfort index based on averages. Index figures will enable managers of all kinds of buildings to judge when they should turn on their air conditioners, and public utilities to judge the power load therefore required.

The discomfort index is the figure 15 added to four-tenths of the sum of the dry and wet bulb thermometer readings. Ordinary household thermometers are dry bulb instruments. Wet bulb ones measure the air's ability to hold moisture.

The discomfort index reaches 75, which many persons find oppressive, when the temperature is 75 degrees Fahrenheit and the relative humidity is 100%. It is also 75 when the temperature is 80 degrees and the relatively humidity 60%, or the temperature is 85 degrees and the relative humidity 30%.

A Consideration of Pupils' Success with Two Methods for Placing the Decimal Point in the Quotient

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The two methods being considered for placing the decimal point in the quotient when dividing by a decimal fraction are: (1) making the divisor a whole number by multiplying by a power of ten; multiplying the dividend by the same number; using the caret ($\wedge$) to signify the new position of the decimal point in the divisor and dividend; and placing the decimal point in the quotient above the decimal point in the dividend and (2) subtracting the number of decimal places in the divisor from the number of decimal places in the dividend and pointing off the resulting number of decimal places in the quotient. There are three major types of examples in division of decimal fractions. These are:

(a) A decimal fraction divided by a whole number, as $2\overline{).6}$

(b) A whole number divided by a decimal fraction, as $.2\overline{)4}$

(c) A decimal fraction divided by a decimal fraction, as $.3\overline{).6}$

It is in the case of the latter two major types that pupils may be taught to apply one or the other of the two methods mentioned above for placing the decimal point in the quotient.

Which one of the methods for placing the decimal point results in greater success for the pupils? Success with an arithmetical method involves understanding the mathematical principle basic to the method and achieving accuracy in performing the steps involved in the method.

Principles Basic to the Two Methods

If the method of making the divisor a whole number by multiplying the divisor by a power of ten and multiplying the dividend by the same number is used, pupils should understand that this is based on the mathematical principle that both terms of the fraction may be multiplied by the same number without changing the value of the fraction.

Likewise, in the method of subtracting the number of decimal places in the divisor from the number of decimal places in the dividend and pointing off the resulting number of places in the quotient, pupils should understand the mathematical principle which is the basis for this method. In the subtractive method the denominator of the quo-

* The writer gratefully acknowledges the cooperation of six sixth grade teachers in four public elementary schools in Austin, Texas. Those cooperating were Mrs. Betty Catlin of Brentwood School, Mr. Horace Dellis of Mathews School, Miss Juliabeth Allamon and Mrs. Alma Blassingame of Wooten School, and Mrs. Margaret Broekema and Mrs. Charlotte Watson of Zilker School.

tient (the number of decimal places in the quotient) depends on the denominators of the dividend and the divisor (the number of decimal places in the dividend and the divisor). For example, hundredths divided by tenths yields tenths. (One decimal place in the divisor subtracted from two decimal places in the dividend results in one decimal place in the quotient.) Pupils should recognize this as an opposite procedure to that used when multiplying decimal fractions. Tenths times tenths yields hundredths as the denominator of the product. (One decimal place in the multiplier plus one decimal place in the multiplicand results in two decimal places in the product.) While addition of decimal places in multiplication is a short cut way of multiplying the denominator of two fractions, subtraction of the number of decimal places in the divisor from the number of decimal places in the dividend is a short cut way of dividing the denominator of the dividend by the denominator of the divisor.

The Problem of This Study

The study being reported concerns the problem of trying to determine with which method pupils are more successful. Aspects studied were:

(1) Are pupils generally more often able to correctly place the decimal point in the quotient when using one method than the other? How well do above-average achievers in arithmetic and below-average achievers in arithmetic perform with each method?
(2) What types of errors are made by pupils using each method?
(3) Can pupils more easily understand the mathematical principle involved in one method than the other for placing the decimal point in the quotient?

Procedure

Six classes at the sixth grade level in four different schools in Austin, Texas, participated in this study which was carried out in the spring of 1958. Three of the teachers agreed to teach the method of making the divisor a whole number by multiplying by a power of ten and multiplying the dividend by the same number. The caret was used by this group to indicate the new decimal place in the divisor and the dividend. A total of 71 pupils in three sixth grade classes were taught this method. The median grade-level arithmetic achievement for these three classes on a standardized test taken in September was 5.8.

The other three teachers agreed to teach the subtractive method

for placing the decimal point in the quotient when dividing by a decimal fraction. A total of 66 pupils in three sixth grade classes were taught this method. The median grade-level arithmetic achievement for these three classes on a standardized test taken in September was also 5.8.

A written description of understandings to be developed in teaching each method was prepared by this investigator and discussed with the teachers who were to teach each method. The teachers were encouraged to try to develop the mathematical understandings involved in the method being taught as well as to try to develop accuracy in using the method to place the decimal point in the quotient.

After teaching the division of a decimal fraction by a whole number as presented in the state-adopted arithmetic textbook, the six teachers taught the following types of division by a decimal fraction:

(1) Division of a whole number by tenths and division of a whole number by hundredths.
(2) Division of a decimal fraction by a decimal fraction.
    (a) Tenths by tenths
    (b) Hundredths by tenths
    (c) Hundredths by hundredths
    (d) Thousandths by hundredths

The teachers who taught the caret method for designating the new decimal place when multiplying the divisor and dividend by a power of ten used the textbook introduction and explanations combined with the emphasis on understandings described by this investigator on the direction sheet. Those teaching pupils to use the subtractive method used the same introductory problem situations presented in the textbook but did not have pupils use the textbook. These teachers developed their own explanation of the subtactive method using suggestions regarding understandings as described by the investigator on the direction sheet. In each of the six classes the introductory lesson, practice, and follow-up discussion were conducted with the class as a whole.

The same practice exercises were used by all pupils in the six classes. Designated pages of exercises in the state-adopted arithmetic textbook and two additional sets of exercises prepared by this investigator were used. The textbook exercises were copied on the chalkboard for pupils learning the subtractive method, so these pupils would not see the other method. All exercises worked by the pupils were checked by the teacher and returned the following day for corrections. Any individual help needed in making corrections was provided. Each teacher helped and encouraged all pupils in trying to understand why errors were made in placing the decimal point.

Testing

When all types of examples in division by a decimal fraction had been introduced and all practice exercises had been worked, checked, and corrected, each teacher administered a test constructed by this investigator. Part I of the test consisted of 12 division examples involving decimal fractions. The same test was taken by all pupils participating in the study. Part II of the test was designed to evaluate the pupil's understanding of the method he was taught to use in placing the decimal point in the quotient. Each pupil was asked to write the rule used in placing the decimal point in the answer to number 12 of Part I. The pupil was then asked to select a statement from among several that best explained *why* the rule can be used to correctly place the decimal point in the quotient. Though the purpose of this part of the test was the same for pupils learning either method, the statements used in this part of the test varied because understandings involved differed with the method taught.

Part I

(1) $.5\overline{)225}$ (2) $5.6\overline{)118.76}$ (3) $\overline{)148.6}$ (4) $2.5\overline{)917.9}$

(5) $1.6\overline{)4.832}$ (6) $.18\overline{)40.6}$ (7) $.12\overline{)1.56}$ (8) $.24\overline{)72}$

(9) $.4\overline{).036}$ (10) $.59\overline{)189.4}$ (11) $8.4\overline{).1262}$ (12) $.24\overline{)9.864}$

Part II

Your teacher will read aloud the statements below. Wait until all the statements have been read before you decide on an answer.

From the statements below place a cross mark (x) in front of the one that best tells why your rule can be used to correctly place the decimal point in the answer.

The statements for the group learning the method of making the divisor a whole number and using the caret to indicate the new decimal place in the divisor and dividend follow.

a. ( ) As long as I make the divisor a whole number by moving the decimal to the end of the divisor and then move the decimal the same number of places to the right in the dividend, this is why the rule can be used.

b. ( ) Multiplying the divisor by 100 makes it a whole number; then when I multiply the dividend by the same number, I am ready to divide. I place the decimal in the answer right above the caret in the dividend.

c. ( ) When dividing I can multiply the divisor and the dividend by the same number and still get the same answer. Multiplying the divisor by 100 moves the decimal point two places to the right and makes the divisor a whole number. Then I must multiply the dividend by the same number. The caret is used for the new decimal places: I am then dividing tenths by a whole number. The decimal in the answer is placed above the caret in the dividend because tenths divided by a whole number gives an answer to the tenths place.

d. ( ) None of these sentences tells why my rule for placing the decimal in the answer can be used. I will write the reason on the back of this page.

The statements for the group learning the subtractive method follow:

a. ( ) As long as I correctly subtract the number of decimal places in the divisor from the number of decimal places in the dividend, this tells me exactly how many places to point off in the answer.

b. ( ) When multiplying decimal fractions, you add the number of places to the right of the decimal in the two numbers you are multiplying. This tells you how many places to point off in the answer when multiplying decimal fractions. Since dividing is the opposite of multiplying, you subtract the number of decimal places in the divisor from the number of decimal places in the dividend. This tells you how many places to point off in the answer.

c. ( ) Dividing thousandths (3 decimal places) by hundredths (2 decimal places) gives tenths (1 decimal place) in the answer. Subtracting two decimal places from three decimal places and pointing off one decimal place in the answer is a short-cut way of dividing thousandths by hundredths.

d. ( ) None of these sentences tells why my rule for placing the decimal in the answer can be used. I will write the reason on the back of this page.

Results of the Study

1. Did pupils more often correctly place the decimal point in the quotient when using one method than the other? Of the 71 pupils taught to multiply the divisor and the dividend by a power of ten and to use the caret to indicate the new decimal place in each, 38 pupils or 53.5% of the group made no error in placing the decimal point correctly in the quotient. Of the 66 pupils taught to use the subtractive method for placing the decimal point in the quotient, 28 pupils or 42.4% made no error in placing the decimal point in the quotient.

Did pupils who were above average in arithmetic achievement more often correctly place the decimal point in the quotient when using one method than the other? For purposes of this study, above-average achievement in arithmetic was arbitrarily set at 6.5 grade-level or above on a standardized test given in September. Among the 71 pupils taught the method of making the divisor a whole number and using the caret to indicate the new decimal place in the divisor and dividend, 13 pupils had an arithmetic achievement of 6.5 or above in September. The range of grade-level achievement for these 13 pupils was 6.5 to 7.7 with a median of 6.8. Eight of the 13 pupils or 61.5% made no error in placing the decimal point in the quotient. The other five pupils made one error each. Among 66 pupils taught to use the subtractive method, there were 14 pupils who had an arithmetic achievement of 6.5 or above in September. The range of grade-level achievement for these 14 pupils was 6.5 to 7.3 with a median of 6.7. Eleven of these 13 pupils or 84.6% made no error in placing the decimal point in the quotient. Of the three pupils making errors, one pupil made one error and the other two pupils made two errors each.

Did pupils who were below average in arithmetic achievement more often correctly place the decimal point in the quotient when using one method than the other method? For purposes of this study, below-average achievement in arithmetic was arbitrarily set at 5.5 grade-level or below on a standardized test given in September. Among the pupils taught to make the divisor a whole number and to use the caret to indicate the new decimal place in the divisor and dividend, 27 of 71 pupils had an arithmetic achievement of 5.5 or below on a test given in September. The grade-level range was 5.5 to 4.2 with a median of 5.1. Eleven of these 27 pupils or 40.7% made no error in placing the decimal point in the quotient. Among the 66 pupils taught the subtractive method, there were 25 pupils who had an arithmetic achievement of 5.5 or below on a test given in September. The grade-level range was 5.5 to 3.0 with a median of 5.0. Of these 25 pupils, only 4 pupils or 16.0% made no error in placing the decimal point in the quotient.

2. What types of errors were made by pupils using each method? The per cent of error by those using each of the two methods on each type of decimal fraction division example included in the test is presented in Table I and Table II. Among the 71 pupils using the caret method, five pupils seemed to have no idea as to how to move the decimal point in the divisor and the dividend and to place the decimal point correctly in the quotient. The errors of these five pupils are not included in data presented in Table I. Among the 66 pupils using the subtractive method, there were six pupils who seemed to have no idea as to how to place the decimal correctly in the quotient. Errors made by these six pupils are not included in the data presented in Table II.

A comparison of the per cent of error for each type of test items indicates a greater per cent of error with one exception by pupils using the subtractive method. There were no errors made by the group using the subtractive method in placing the decimal point in the quotient when dividing a decimal fraction by a decimal fraction with the denominators the same, as tenths by tenths. Of course, no decimal point should be placed in the quotient in this type of decimal fraction division and no pupil did so. Those taught the subtractive method indicated a greater tendency to forget to place the decimal point in the quotient when dividing a decimal fraction by a whole number. With this type both groups followed the same method which was to place the decimal point in the quotient above the decimal point in the dividend.

In applying each method to items 1 and 8 in the test, the addition of zeros in the dividend was necessary. Failure to add these necessary

TABLE I

PER CENT OF ERROR IN PLACING THE DECIMAL POINT FOR EACH TYPE OF DECIMAL FRACTION DIVISION EXAMPLE BY 66 PUPILS TAUGHT THE METHOD OF MAKING THE DIVISOR A WHOLE NUMBER

Type	Test Item Number	Average Number of Errors	Per Cent of Error
1. Decimal fraction divided by a whole number	3	4.0	6.1
2. A whole number divided by a decimal fraction	1, 8	5.5	8.3
3. Decimal fraction divided by a decimal fraction (denominators the same, as tenths divided by tenths)	4, 7	1.5	2.3
4. Decimal fraction divided by a decimal fraction (denominator of the dividend larger, as hundredths divided by tenths)	2, 5, 12	1.7	2.6
5. Decimal fraction divided by a decimal fraction (denominator of divisor larger, as tenths divided by hundredths)	6, 10	1.0	1.5
6. Decimal fraction divided by a decimal fraction (denominator of dividend larger; with zero in tenths place of the quotient	9, 11	11.5	17.4

TABLE II

PER CENT OF ERROR IN PLACING THE DECIMAL POINT FOR EACH TYPE OF DECIMAL FRACTION DIVISION EXAMPLE BY 60 PUPILS TAUGHT THE SUBTRACTIVE METHOD

Type	Test Item Number	Average Number of Errors	Per Cent of Error
1. Decimal fraction divided by a whole number	3	8.0	13.3
2. A whole number divided by a decimal fraction	1, 8	7.5	12.5
3. Decimal fraction divided by a decimal fraction (denominators the same, as tenths divided by tenths)	4, 7	0	0
4. Decimal fraction divided by a decimal fraction (denominators of the dividend larger, as hundredths divided by tenths)	2, 5, 12	4.0	6.7
5. Decimal fraction divided by a decimal fraction (denominator of divisor larger, as tenths divided by hundredths)	6, 10	8.5	14.2
6. Decimal fraction divided by a decimal fraction (denominator of dividend larger; with zero in tenths place of the quotient)	9, 11	12.0	20.0

zeros in the dividend was a common cause of errors made on these two items. Failure to add these necessary zeros in the dividend occurred a little more often among those taught to use the subtractive method.

Dividing a decimal fraction by a decimal fraction when the denominator of the divisor is larger, as tenths divided by hundredths, caused more difficulty in regard to placing the decimal point in the quotient for pupils taught the subtractive method. This type of division example is represented by test items 6 and 10. For pupils taught the method of making the divisor a whole number and multiplying the dividend by the same number, it was necessary to add a zero in the dividend. Pupils taught the subtractive method needed to add a zero in the dividend to make the denominator of the decimal fraction in the dividend the same as the denominator of the divisor. Those taught to use the subtractive method more frequently failed to add the necessary zero in the dividend and pointed off one decimal place in the dividend after subtracting one decimal place in the dividend from two decimal places in the divisor.

When dividing a decimal fraction by a decimal fraction as in test items 9 and 11 in which it was necessary to place a zero in the tenths place of the quotient, errors occurred with about equal frequency among pupils taught either method. Of 66 pupils making the divisor a whole number and using the caret, 17.4% were in error in handling the decimal point and placing a zero in the quotient. A frequent cause of this error was failure to place a zero in the tenths place of the quotient and resulted in an answer such as

$$8.4\wedge)\overline{.1262}\quad .15\ R2$$

Of 60 pupils using the subtractive method, 20% were in error on this type of decimal fraction division. Those using the subtractive method who made an error on this type recognized the need for three decimal places in the quotient and added a zero because the subtractive method clearly indicated this. However, the zero was placed incorrectly with such resulting answers as .150 R2 or .105 R2.

Another observation of interest to this investigator was the fact that misplacing quotient figures caused considerable error among pupils taught to make the divisor a whole number and to use the caret to indicate a new decimal place in the divisor and dividend. This type of error is illustrated below:

$$5.6\wedge)\overline{118.7\wedge6}\quad 2.12$$

The pupil who uses the subtractive method does not misplace the decimal point because of failure to place the quotient figures correctly. Again this division with quotient figures wrongly placed is shown below, but the pupil using the subtractive method keeps in mind that there must be one decimal place in the answer and points off correctly.

$$5.6\overline{)118.76}\quad 21.2$$

Of course, any child who misplaces quotient figures is likely to place too many or too few figures in the quotient which would result in an error with any method of placing the decimal point in the quotient.

3. Did pupils more easily understand the mathematical principle involved in one method than the other for placing the decimal point in the quotient? Among the 71 pupils taught to make the divisor a whole number and to use the caret to indicate the new decimal place in the divisor and dividend, the responses of only 66 were considered when studying understanding. Five pupils seemed to have no idea as to how to use the method. As stated earlier the pupils were asked to write the rule they used in deciding where to place the decimal point in the quotient on item 12 in the test. Next the pupils were asked to select a statement which best explained the meaning of this rule or why this rule could be used. The statements for each method from which pupils made a selection have already been described as Part II of the test. The fact was also clarified that these statements necessarily differed with the method taught. Fifty-one pupils using the caret gave such rules as, "I counted over two places in the divisor and two places in the dividend. I changed the divisor to a whole number and moved the decimal the same number of places in the dividend. I did the same to the divisor as I did to the dividend." In selecting a statement judged as the best reason why their rule could be used, 32 pupils selected statement (a); 20 selected statement (b); and 10 selected statement (c). Four pupils wrote their own explanations, as "What you do to the divisor you must do to the dividend."

Only 60 responses from pupils taught the subtractive method were studied since six pupils of the original group of 66 seemed to have no idea as to what the rule was or how to apply it. Of these 60 pupils 53 wrote their rule used on item 12 in the test as, "I subtracted the number of decimal places in the divisor from the number of decimal places in the dividend and pointed off that many places in the answer." Eight pupils stated, "I divided thousandths by hundredths and pointed off tenths in my answer." In selecting a statement judged as the best reason why their rule could be used, 26 pupils selected (a); 17 selected (b); and 17 selected (c).

It is recognized that some of the students from each of the experimental groups probably guessed as to which explanation they might be expected to select in Part II of the test. However, it is judged by this investigator that Part II of this test for pupils taught each method does give some indication of the pupils' understanding of the rule or method they were applying. It appears that about half of the pupils taught to make the divisor a whole number and use the caret to indicate the new decimal place in the divisor and the dividend favored the purely mechanical explanation of this procedure as represented by statement (a) rather than statements presenting more of the mathematical principle involved as in (b) and (c). Statement (c), which presented the more complete explanation of the principle involved, was selected by 16.7% of the 66 pupils.

A little less than half the pupils using the subtractive method appeared to favor the mechanical explanation of this procedure as represented by statement (a). Statement (c), which represented the more complete explanation of the principle involved, was selected by 28.2% of the 60 pupils.

CONCLUSIONS

1. In general, pupils taught to make the divisor a whole number by multiplying by a power of ten and to multiply the dividend by the same number and use the caret more often correctly placed the decimal point in the quotient than pupils who were taught the subtractive method. The above-average arithmetic achievers, in the sampling of pupils taught the subtractive method, more often correctly placed the decimal point in the quotient than the above-average achievers taught the other method. However, this difference was very slight.

For the below-average arithmetic achievers the subtractive method was decidely more difficult than was the method of making the divisor a whole number.

2. Failure to place the necessary zeros in the dividend for examples such as, $.24\overline{)72}$, was common to those using either method. However, those using the subtractive method more often failed to add the necessary zero in the dividend in such an example as, $.18\overline{)40.6}$. Failure to place a zero in the tenths place of the quotient for such examples as, $8.4\overline{).1262}$, was common to pupils using either method. Those using the subtractive method recognized a need for the zero but often placed the zero in the wrong place in the quotient.

3. The nature of the subtractive method seems to provide more opportunity for error in placing the decimal point in the quotient than does the other method.

4. It is recognized that the introductory presentation given by

teachers using the subtractive method may have varied much more than those presentations given by the other teachers through using the textbook as a guide. However, there was considerable indication that children taught the subtractive method understood the mathematical principle basic to it as well as pupils taught to make the divisor a whole number and to use the caret to indicate each new decimal place.

RECOMMENDATIONS

1. The short-cut way of thinking or the short-cut rule for either method is economical and most pupils using either method will reach a final rule which is rather mechanical. The teacher, however, should frequently check on the pupils' understanding of the procedure being used in an effort to keep this understanding alive.
2. This was an exploratory study and the sampling of pupils learning each method was rather small. It is the opinion of this investigator that a similar study on a large scale should prove very enlightening as to the advantages and disadvantages in each of the methods considered for placing the decimal point in the quotient.

FIND X CHROMOSOME IN MAN THREE TIMES LARGER THAN Y

The chromosome that helps determine sex in humans—the X chromosome—has been found to be three times larger than the Y chromosome, two geneticists report.

Since the female has two X chromosomes while the male has one X and one Y, this may help explain some of the differences between the sexes.

As a consequence of the larger size of the X chromosome, the human female cell is about four percent greater than the male in chromosome volume. Thus, the female has a "substantially richer genetic capacity."

SALT IN SALMON FLESH MAY BE FACTOR IN MIGRATION

How salty a salmon is may be an important influence on its migratory habits. Apparently there is an adjustment in sodium and potassium content of salmon flesh when the fish migrate from sea to fresh water or from fresh to sea water. The season of the year, the fish's age, sex and species, and "probably also hormone interrelations" may determine the concentration of these salt ions in the flesh.

Coho salmon caught at the river mouth along their spawning migration route had a lower sodium ion level than fish at sea. Farther up river, the level dropped to less than one-half what it was at sea. Potassium levels were higher than in mature fish caught at sea.

There was some difference noted with sockeye salmon, however. While heading up river, these salmon also had a lowered sodium ion level but a raised potassium level. Yet, once sockeye had entered fresh water, the ion concentration for these important salts was restored to levels maintained at sea. Evidence was obtained that the male fish was the first to adjust with a rise in sodium and a decrease in potassium.

Certification Requirements in Mathematics and Science

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The Problem

The teaching of science and mathematics throughout the high schools of the country is an area of genuine concern today. Lay and professional critics of public education have pointed out the inadequacies of *how* and *what* is taught in science and mathematics courses in the public schools. All states endeavor to exercise some control of the content and method of such courses by certifying teachers. The writers, dealing with certification problems of student advisees in a large eastern university, became interested in the science and mathematics certification requirements for teachers throughout the United States. What are these requirements? How adequate are they? How much course work is required in professional education before a college graduate can legally teach in the various states? The present study reports an investigation of this problem.

Several related studies have been reported. In an exhaustive study of over eleven hundred secondary science teachers in the state of Kansas, Brooks and Baker (1) reported that 16 per cent had no college credit in biology, botany, or zoology. Further, 29 per cent had not taken chemistry, 45 per cent had no zoology, and 49 per cent had no physics. Burnett (2) reported a study by Nelson in Illinois in which seven out of 119 teachers had no background in biology, 91 had none in geology, 102 had none in meteorology, and 104 had none in astronomy. In another study, also cited by Burnett, 277 teachers in California out of the 1,552 who reported had neither a major nor a minor in science fields, while 364 had only a minor. Other studies reviewed by Burnett generally indicated the inadequate preparation of the personnel then teaching science in the various places studied.

The Procedure

To determine the certification requirements in mathematics and science the authors requested from each of the 48 states' departments of education their requirements for certifying teachers of those subjects. Forty states complied, and the information for the remaining eight states was obtained from a current bulletin (4).

Since much of the concern regarding teaching in these two areas relates both to the quantity and quality of teachers' preparation, this report directs itself to the ***minimum requirements possible*** in the various states; that is, to the minimum number of semester hours of college work in these two subject matter fields necessary for certifica-

tion. It was felt that such a procedure would enable the authors to determine *how little* academic preparation it is possible to get by with throughout the country in these teaching fields. The minimum number of hours required in professional courses in education was also ascertained.

The Results

Forty-two states required a four year college degree and one state demanded five years of college preparation. On the other hand, three states will permit persons with 60 semester hours of college work to teach on the secondary level, and two states will permit persons who have 90 semester hours credit to teach. Only six states required more academic preparation for more advanced certificates, and four of these were states which would accept teachers with less than four years of college work in the first place. In other words, of the 43 states which required four or more years of college work for teaching, only two required additional academic preparation in the subject matter teaching field by those persons who work for advanced degrees and higher certificates.

Table 1

Semester Hours Required in Science, Mathematics, and Professional Education Throughout the United States

Subject Matter Area	Range	Mode	Mean
Mathematics	0–24	18	15.1
Science	0–48	15	17.9
Professional Education	12–24	18	18.4

Table 1 shows the range, mode, and mean number of semester hours required in each of the various areas under study. In the field of mathematics the certification requirements ranged from zero to 24 semester hours required. The modal value was 18, with a mean of 15.1 semester hours of mathematics as the minimum required for certification. Further, three of the 48 states will accept up to six semester hours credit for courses taken while in high school, and two others will give credit for up to three hours of high school mathematics toward certification requirements.

For science teachers the certification requirements throughout the country ranged from zero to 48 semester hours of college work required. This range, however, is somewhat misleading, since the mode of 15 and mean of 17.9 semester hours is considerably lower than might be expected. One state will accept up to six semester hours credit for courses taken while in high school. In addition, only 20

states specified particular areas of study which must be included for the prospective teacher, while 28 states made no mention of specific areas. Of the 20 states which did require course work in particular areas in science (such as biology, chemistry, or physics), only eight specified a minimum number of hours work to be completed, while the remaining 12 states simply required "some."

The minimum number of hours required to teach any one science (viz., biology, chemistry, or physics) varied from zero to 24 semester hours, although many of the states made no special mention to distinguish certification requirements between general science and a particular science subject to be taught. It was noted that in many of these same states the requirements for other subject matter areas were often quite precise. For example, the requirements for some of the more recent additions to the curriculum such as driver training, physial education, and home economics, to name a few, were generally stated quite explicitly.

One state required grades of *C* or higher in all course work taken beyond the sophomore year, but no other mention of minimum grades was found.

The number of hours required in professional courses in education ranged from 12 to 24, although 21 states required 18 semester hours (mode). The mean number of semester hours required in professional education courses was 18.4, with only one state not specifying exactly how many were required.

Discussion of Results

What do these data mean? Are the requirements throughout the United States for certification in mathematics and science adequate? What comprises adequate preparation for teachers of these subjects, and what is it that makes this preparation adequate?

Having no set, accepted standard against which to compare, the authors are reluctant to say how much is enough. The data in this study, however, seem to indicate that certification requirements for teachers of mathematics and science throughout the United States are not generally agreed upon and not generally high. In other words, there seems to be considerable lack of agreement among the states upon what constitutes acceptable minimal standards, although most states agree fairly well upon the amount of professional education required for certification.

Further, most of the states are vague in setting forth the specific subjects which a prospective science or mathematics teacher must have before he can be certified to teach. Almost without exception no mention is made regarding the quality of this preparation, either. That is, a prospective teacher could complete the number of hours

required for his teaching field of mathematics or science with minimum grades, i.e., all *D*'s, as long as he maintained a grade point average satisfactory for graduation, and still be certified to teach in these particular subject matter areas.

It seems that many of the inadequacies which currently exist in various states' certification laws can and should be remedied by teacher education institutions. The various colleges and universities can insist upon higher than the minimal requirements in academic preparation. Obviously this is already being done in many places; the authors simply wish to suggest that all institutions engaged in preparing mathematics and science teachers consider the possibility of carefully evaluating their own institutional programs and minimum requirements.

Finally, there seems to be a definite need for some sort of uniform minimal code of requirements for certification throughout the United States. Perhaps a study of the problem by certification officers from all of the various states meeting under the auspices of the National Education Association or the American Association of Colleges for Teacher Education or the American Association for the Advancement of Science would prove instrumental in upgrading the current deficiencies. Out of such a meeting might come a program such as Watson (3) suggested in which full year courses in biology, chemistry, mathematics, and physics totalling approximately 32 semester hours as a foundation program "for any prospective science teacher, irrespective of his special interests" would be required. As Watson pointed out, the Steelman Report made such recommendations as far back as 1946, but so far these appear to have gone unheeded.

Dare we continue to ignore these recommendations? Is it possible that we can get more and better science teachers by having low minimum requirements? Can teachers' organizations observe the problem of inadequate standards without taking action and still profess professional status? Can state legislatures or education boards justify creating situations wherein prospective teachers spend two or more years in general education and sometimes less than one full semester in teaching field subject matter area preparation? Can the general public criticize school administrators or teacher education institutions for not requiring more adequate preparation and then refuse to support the increased costs necessary to attract capable young people into these fields? Are college teachers of science and mathematics adequately prepared in their own special areas?[1] Do states actually adhere to their written requirements, or do they sometimes "say one thing and do another?" Does certifying prospective teachers in more

[1] See *NEA Research Bulletin*, February, 1958, p. 14.

than one teaching field reduce, perhaps to the point of diminishing returns, the adequacy of their preparation?

The authors feel that these questions deserve serious consideration and then, perhaps, vigorous action by any and all concerned.

References

1. Brooks, Merle E. and Baker, Weldon N. "A Study of Academic Preparation of the Secondary Science Teachers of Kansas," *The Science Teacher*, October, 1957, 277–280.
2. Burnett, R. Will. *Teaching Science in the Secondary School*, New York: Rinehart, 1957.
3. Watson, Fletcher G. "Course Requirements for Future Science Teachers," *The Scientific Monthly*. December, 1957. 32–323.
4. Woellner, Robert C. and Wood, M. Aurilla. *Requirements for Certification*. Chicago: University of Chicago Press, 1957.

CHEMISTRY TESTS

The Examinations Committee of the American Chemical Society and the National Science Teachers Association announce the availability (April 1, 1959) of the Form 1959, *NSTA-ACS Cooperative Test in High School Chemistry*. This is a new test designed as an end-of-year achievement test in high school chemistry. The test is the result of the cooperative effort between a committee of active chemistry teachers and experts in test construction. Technical advice has been furnished by the Testing Bureau and Statistical Department of St. Louis University.

For further information or tests write:

Examinations Committee—ACS
St. Louis University
1402 South Grand Blvd.
St. Louis 4, Missouri

FORMER GENERATIONS PROBABLY EXPERIENCED RADIOACTIVITY

Our ancestors of 200 or more years ago probably bumped into as much radioactivity as we do today.

Scientists do not have definite proof, but they suspect that former generations were exposed to radioactivity as much as people living in the atomic age.

Until fairly recently, sanitary conditions were such that people did not bathe, or even wash their hands frequently. Since radioactivity can be washed off the body, present day sanitary facilities would tend to reduce the amount of radioactivity on the body. Likewise, the lack of facilities years ago probably means that while there were no atomic blasts and fallout, a person still carried radioactivity on his body in granules of dust, soot and accumulated dirt.

Pre-atomic age radioactivity was caused by naturally occurring radioisotopes and cosmic radiation.

STEEL WASTE AIDS CROPS

Ferrosul, a waste material of steel manufacture, shows promise as a source of trace minerals for growing crops on soils where these minerals are lacking. Plants were grown in a greenhouse using ferrosul to provide calcium, sulfur, magnesium, iron and manganese. Plants were unharmed as long as "extremely large quantities" of material were not applied to the soil. Eventual use of ferrosul, which is not commercially available, needs more study, researchers indicate.

Variable Paradox*
A Dialog in One Act

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CAST

The Teacher. An enthusiastic student of contemporary mathematics, who brings into the classroom the same concept of variable that he uses in modern logic and foundations of mathematics.

The Student. One who is thoroughly, and (he thinks) securely saturated with the notion of variable which prevails in traditional high school mathematics courses (and [we might as well add] in traditional college undergraduate mathematics, too). That is, he thinks that the 'x' in '$2+x=5$'[1] is a temporary name for the number, 3. He thinks that solving equations is like finding familiar synonyms for unfamiliar words.

I. *Teacher:* If 'The ceiling is one thousand feet' is a true statement and 'The landing strip is clear' is a true statement, then what do you know about the statement, 'The ceiling is one thousand feet and the landing strip is clear'?

Student: It is true also. The conjunction of two true statements is always a true statement.

Teacher: If 'The ceiling is one thousand feet' is a false st tement and 'The landing strip is clear' is a false statement, what do you know about the statement, 'The ceiling is one thousand feet or the landing strip is clear'?

Student: Obviously, it is false. When both components of an alternation are false, the whole statement is false.

II. *Teacher:* Examine the sentence:

$$x+2=x.$$

Is it true or false?

Student: It is false.

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* Some aspects of the presentation at the Mathematics Section; CASMT Convention, Indianapolis, Indiana, November, 1958.

† For the paradox to be resolved in this little "lesson plan," the writer acknowledges her indebtedness to Herbert E. Vaughan, Mathematics Consultant and Editor of the Mathematics Project of the University of Illinois Committee on School Mathematics. This article and the other work of the project has been made possible by a grant from the Carnegie Corporation of New York.

[1] For an explanation of the use of single quotation marks, please see: Chapter III, pp. 28–36 in *Godel's Proof*, by Ernest Nagel and James R. Newman, New York University Press, 1958.

Teacher: What makes you think so?

Student: If it were true, 'x' would have to be a synonym for the name of some number, and there isn't any number which can be increased by two and still be the same.

III. *Teacher:* Examine the sentence:

$$x+x=2x.$$

Is it true or false?

Student: True, of course.

Teacher: How do you know?

Student: That's easy; 'x' is a synonym for the name of any number whatever.

IV. *Teacher:* Now examine the sentence:

$$x+2<0.$$

Is it true or false?

Student: True.

Teacher: If so, 'x' must be a name of something. What does it name?

Student: 'x' is a synonym for the name of any number which is less than -2.

V. *Teacher:* Examine the sentence:

$$x+2\geq 0.$$

Is it true or false?

Student: True.

Teacher: What does 'x' name this time?

Student: Any number greater than or equal to negative two.

VI. *Teacher:* If '$x+2<0$' is true and '$x+2\geq 0$' is true, how must I classify:

$$x+2<0 \quad \text{and} \quad x+2\geq 0.$$

Student: True. The conjunction of two true statements is true.

Teacher: Tell me what 'x' names this time.

Student: But—but—there *isn't* any number which is both less than -2 and equal to or greater than -2!

Teacher: But isn't that the kind of reason you gave me a few minutes ago for saying that '$x+2=x$' is false?

Student: Oh! [Long pause] I must change something.

Teacher: Change what?

Student: I will have to say—um-m-m—I must say that sentences such as '$x+2<0$' and '$x+2\geq 0$' are false. Oh, I see! I shall have to say that '$x+2<0$' is false because I can think of numbers for whose names 'x' is *not* a synonym. Similarly '$x+2\geq 0$' is false.

Teacher: Then what about the sentence:

$$x+2<0 \quad \text{or} \quad x+2\geq 0.$$

Student: That is false, also.

Teacher: Why?

Student: Because the alternation of two false statements *has* to be false. That is what 'or' means.

Teacher: Tell me a number, x, for which it is the case that '$x+2<0$ or $x+2\geq 0$' is false.

Student: But—but there *is* no such number! Every number "works." I mean every number plus 2 is either less than 0 or greater than or equal to 0.

Teacher: I agree. But is not that the same reason that you gave me for saying that '$x+x=2x$' is true?

Student: [Long pause] Excuse me, sir, but I think I must be needing a vacation. Perhaps after the holidays . . .

Teacher: Perhaps we both might have greater peace of mind during the holidays if we would abandon the notion that a variable in a mathematical sentence is a synonym for the numerals, if any, which make the sentence true. Of course, at the same time, we must abandon the notion that open sentences can be classified as true or false, or else abandon our interpretation of conjunctions and alternations, that is, of compound sentences in which the connectives 'and' and 'or' are used. Perhaps a sentence containing variables is not a statement at all unless the variables are quantified.[2] A variable must be just a hole in a sentence making the sentence uninterpretable until the hole is filled by a name which makes sense. After such a replacement, we may interpret the resulting sentence and arrive at a judgment as to whether it be true or false. Think it over. Happy Holidays.

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[2] Notice that we can classify the following as true or false without becoming involved in contradiction:

In the sentences below, the domain of 'x' is the set of all real numbers. That is, the names of all real numbers are permissible replacements for 'x' to obtain instances of the generalizations.

For each x, $x+2=x$.	False
There exists x such that $x+2=x$.	False
For each x, $x+x=2x$.	True
There exists x such that $x+x=2x$.	True
For each x, $x+2<0$.	False

There exists x such that $x+2<0$.	True
For each x, $x+2\geq 0$.	False
There exists x such that $x+2\geq 0$.	True
For each x, $x+2<0$ or for each x, $x+2\geq 0$.	False
For each x, $x+2<0$ or $x+2\geq 0$.	True
There exists x such that $x+2<0$ and there exists x such that $x+2\geq 0$.	True
There exists x such that $x+2<0$ and $x+2\geq 0$.	False

The writer would like to point out that our naive classification of open sentences as true or false in centuries past has been evidence of the two kinds of unverbalized awareness symbolized by the existential and universal quantifiers. The person who maintains that '$2+x=5$' is true, is really thinking, "There exists a number x such that $2+x=5$." The person who says that '$2+x=5$' is false, is thinking, "It is not the case that for each number x, $2+x=5$." The person who insists that '$b+1=b$' is false, may be thinking that it asserts that there *exists* a number b such that $b+1=b$. The open sentence, '$b+1=b$', does not assert anything. Nor does '$x+x=2x$' assert anything. Neither gives us anything to affirm or deny until we change it in *one* of two ways:

1. Replace the variable with a numeral.
2. Prefix a quantifier to the sentence.

TEMPERATURE AND MOISTURE AFFECT CITRUS FRUIT TENDERNESS

A coastal orange is not as "tough" as one grown in the interior, two agricultural researchers have found.

There is a definite relationship between climate and citrus fruits' storage life and susceptibility to injury.

Tests in southern California in which coastal grown lemons, grapefruit and oranges were compared with citrus fruits grown in the drier, warmer interior showed the coastal fruits were more tender. Such fruit is also more susceptible to injury by fumigation and oil sprays; its storage life is also short compared with fruit grown in the interior.

Air temperature and evaporation probably affect the fruit in a way similar to the responses induced in leaves. However, the complex structure of the fruit makes it more difficult to study than the leaves.

In all the districts, ranging from the coast to the desert, it was found that fruits taken from the tops of trees "where they would be subjected to greater water stress" were less tender and had a lower percentage of moisture.

INTENSE ATOM REACTOR HEAT MAY CATALYZE CHEMICALS

The intense radioactive heat found deep in the heart of an atomic reactor may offer a promising way of making chemicals more easily and profitably. A "chemical reactor" has been proposed for production of nitric acid.

The Atomic Energy Commission has been asked to study feasibility of irradiating air in an air-cooled type reactor to make nitrogen oxide—which is the precursor to nitrogen dioxide and nitric acid.

This is such an early development it is very difficult to assess, but the possibilities look bright and encouraging, and there may be other instances of where chemical reactions may be profitably catalyzed by the intense radiation in atomic reactor.

"Better Now—or Now" . . . Two Views of an Elementary Science Program

Sister Jean Marie, R.S.M.

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When the optometrist asks his patient to determine which of two possible positions of a lens helps him to see better, a judgment must be made. At first sight, the difference may seem very slight, yet the patient selects the clearer view to avoid later headaches. The purpose of this paper is to present the view which, to the curriculum committee of Saint Xavier College, clarifies the teaching of the world of nature to children. How the committee members arrived at their clear view might well be reviewed.

Dissatisfied, as were so many others, with the existing systems of college organization and curriculum, research and experimentation were begun by members of the Saint Xavier College faculty in 1934. One of the most important results of this research was the Self Study begun in 1950, published in 1952, and carried on for the past several years by the college faculty and cooperating elementary and secondary schools.

The need for a curriculum that would represent the continuum of education from the first grade through college, together with the problem of articulation between the elementary, secondary, and college levels, led to the wise decision to invite teachers and administrators from the lower levels to join the college faculty in the study. The Sisters of Mercy who conduct the College have a distinct advantage in making a study involving experimentation. Fifty-four elementary and seven high schools in the Chicago area are taught by these sisters. Although full experimentation was not carried on in all of the schools, faculty members from many of them participated in the summer workshops and many of them experimented with the curriculum in their teaching.

Briefly, the curriculum which has resulted stresses the liberal arts, preparing the child in the elementary school by means of an integrated program to complete the skills necessary for entrance to the liberal arts high school. Here emphasis is placed on the development of critical thinking and the liberal arts' skills. To show how this close articulation helps, one instance may be cited: A second language is taught at the elementary level, so that more progress is possible at the secondary level, and the language may be used as a source of material for other areas at the college level.

The following is merely an outline of the vertical structure of the science curriculum. At the primary levels which correspond to the first three years of school, the child is introduced to the world of

nature. The approach is through the beautiful, the wonderful, the awe-inspiring things of the physical world. The goal here and in the next three levels is to give the child many experiences which are calculated to give the knowledge and appreciations basic to scientific study in later years. In the primary years the concepts are integrated with religion, mainly the Bible story, and with the social studies. These are the themes: a loving Father creates the world for man's use; the law of God for man is reflected in the natural law seen in all living and natural non-living phenomena; and man's responsibility to use all created gifts properly. At the fourth, fifth and sixth levels, the content is more autonomous but is integrated with the social studies and religion, the themes being the order in the universe, the rational use of material things and man's maintenance of order in the world. Our curriculum provides for completion of elementary school by the end of six years for those who are above average. However, some complete the work in seven or eight years, since individual differences require more time for the average and below average child.

In the ninth grade, when interest in self is high, the science content is built around man, his physiology and psychology. The course called "Man in His World" is planned for two years' study. It combines the physical sciences, such as chemistry of digestion, the physics of light, and sound as they are related to the various systems of man. In the tenth grade, the emphasis is on the world about man, plant, and animal life, energy and conservation.

In the eleventh and twelfth years, the student studies physics and chemistry with application of mathematics and the logic studied in English.

The philosophical approach is used in the college. During freshman and sophomore years all students are required to study Natural Science. During four semesters the student investigates the philosophy of Natural Science as exemplified in the biological, physical, and psychological sciences.

This vertical description is necessarily brief. For a more detailed description of a total Natural Science program in the Saint Xavier curriculum reference may be made to a recent article written by Sister Mary Muriel, R.S.M. in the September, 1958 issue of the *Catholic Educational Review.*

We call our elementary school program "Nature Study," and it may be asked why we use such an antiquated term. Most definitions of the word "science" include the idea of "a body of organized knowledge of truth systematized and unified by general laws or principles." Accumulated knowledge is formulated and systematically arranged with reference to general truths, arrived at according to accepted methods.

Certainly, what we do at the elementary level is not science in this sense of the word. We propose to lead the child by observation and personal experience, to a factual knowledge of the nature of creatures and physical phenomena, and at the same time to further the development of attitudes of wonder, appreciation and reverence for the beauties of the world of nature. Our goal is not to produce scientists, but to prepare a child for living in a moving, changing world; to bring him into close contact and familiarity with the things and experiences which will enrich his childhood and equip him with what he needs for the more mature studies which he will pursue later in a scientific and philosophic manner. Hence, the term "Nature Study" better designates the things we are trying to accomplish.

The term "Nature Study" does not imply the inclusion exclusively of biological experiences. It also concerns itself with forms of energy, rock and soil formation, weather and climate, in short, all natural phenomena. It is definitely not a "watered-down" college biology nor high school general science course.

The philosophical and theological thought of Saint Thomas Aquinas is the guiding force of the Saint Xavier College Plan of Education. From the general principles, basic to the total program for the education of the Christian person, we derive specific ones which guide us in the choice of content, method, and approach.

The first two principles, namely, "As a thing acts so it is," and "Nothing is in the intellect that is not first in the senses," are closely related and equally forceful in directing us toward emphasis on observation of the things of nature. By the application of the senses, the child perceives how living things behave—their locomotion, nutrition, growth, adaptations. He also learns the sensory characteristics of both living and non-living things, such as color, form, texture, size, fragrance and the like, thus arriving at a concept of the true *nature* of the thing. While recognizing what things are, the child grows in the development of sensory skills. He becomes more aware of sounds, sights, odors, and more accurate in his recognition of things for what they are.

Sensory images are best acquired through actual contact with the things of nature. Therefore, every effort is made to provide personal experiences. Since the teacher is responsible for setting the stage for meaningful experiences, she must be aware of the nature of the senses and their objects. She must be conscious of the sensory knowledge possible in a given situation, and must appeal to all the senses possible. Through handling, smelling, listening, tasting, and then reflecting on these notes, the child arrives at a greater knowledge of the nature of things than he would by making a papier maché model, a diorama, or a picture. Only when personal experiences are impossi-

ble do we reluctantly rely on the vicarious. Pictures, film strips, moving pictures, and the like should depict things as naturally as possible, otherwise we build imperfect concepts of the nature of things.

Another principle, "Proceed from the more known to the less known," directs the selection of materials for study from the child's immediate environment—the living and non-living things in and around his home, the school, the neighborhood. Using the familiar natural object, the child is guided to truths that are not so obvious, to appreciations, to attitudes.

This principle also determines the content according to the level of development of the child. Scientific phenomena are not presented to the child before he is psychologically ready to grasp the meaning of such experiences. Scientific reasons for natural phenomena are not given before he has reached the maturity necessary for such understandings.

At the level of the child's interest and ability, the utility of natural things is studied. Thought is given to whether observed living and non-living things help or hinder man. Right values are developed. Man is seen as the highest creature of this world with a duty to control, to care for, and to conserve the world of nature which is his environment. Since lower creatures are for man's use, their perfection is measured by their contribution to man's perfection. Man's perfection, in turn, is furthered by his proper use of the things of nature. Thus an attitude of reverence for other creatures is developed.

Further clarification of the kind of materials presented for observation is provided by another principle: "The world consists of many primary natural units which undergo many changes." The whole natural unit is observed rather than its parts. A tree is studied rather than the leaves of many trees; a specific plant as a whole rather than a study of seeds or flowers of a variety of plants. The gross structure and obvious functions are basic to later detailed study. Many kinds of individual wholes, living and non-living are considered. Observable states and changes are noted such as the development from egg to maturity, of seed to fruiting plant, conditions and changes of weather, the soil, the heavenly bodies and simple cause and effect relations.

This knowledge of the variety of individual wholes, together with the observation of the orderly changes, and cause and effect relations give evidence that the universe is "a great and beautiful system." Perfect order in the coordination of created things directs the mind of the child to God, the Primary Cause, the only ultimate explanation for the wonders he observes.

These principles not only influence our emphasis on observation, but they also direct us to an aesthetic approach in teaching. What

do we mean by this? Is it the approach which made the old nature study movement objectionable? No, this is not an attempt to teach in an emotional way.

Saint Thomas Aquinas tells us "Beautiful things are those which please when seen." Things that are beautiful possess the characteristics of unity, truth and goodness. Our study of natural objects or phenomena as natural units accents their *unity* or wholeness. Our search for the nature of things emphasizes the *truth* about creatures. Our recognition of the perfection of creatures in their order and utility in God's plan indicates their *goodness*.

The aesthetic approach, then, is intended to give the child a true picture of the things of nature. It is this approach which justifies the use of the term, "nature study." In practice it has to do mainly with the learning materials used. Natural things are created beautiful. That is why they are the best material for nature study. Only those audio-visual aids which will develop concepts of the beauty of the object, its wholeness and goodness should be used with the young child. Materials that personify or depict animals as human or that explain natural functions through an analogy with mechanical devices are unnatural and consequently undesirable. The cartoon type of film strip, in some cases giving faces to plants, and human expression to animals, are not beautiful nor true. In using them we render the child a disservice. Such techniques lead to false ideas which have to be unlearned when scientific principles are introduced at a higher level.

Other areas of the child's study offer materials which may aid in building his ideas of the truth, unity and goodness of natural things. Poetry, music, literature, and art all have contributions to make. An anthology of children's literature reveals many excellent lyric nature poems which offer the child an insight and stir his imagination. Listening to records of fine music which include sounds of nature, reading well-turned phrases of prose from the writings of naturalists, will, if presented properly, become part of the child's aesthetic equipment for life.

Rather than the mediocre type of pictures or the cute but unnatural animal prints so commonly used, the works of the great masters are being examined by our teachers for materials which will not only give a true picture of natural phenomena but also increase appreciation and understanding of the fine arts.

The correlation of literature and the fine arts with nature study is one phase of the technique which is part of the Saint Xavier Program. Another important aspect is that of integration. Too often the child's knowledge is atomistic. He sees no relation between the many experiences he has and the facts he learns. His knowledge should pos-

sess a quality of wholeness. It is to achieve this unity that integration is used.

There is an interrelation of the content of the three areas of nature study, religion, and social studies. At the primary levels the scriptural theme interpenetrates the nature study and social studies: the story of Creation suggests the introduction of the various kinds of creatures, living and non-living; the giving of the moral law to man is paralleled by the natural law observed in the world of nature; and the consideration of our proper use of God's gifts to man in religion has a bearing on our utility of the world of nature.

At the three levels beyond the primary, the history of man provides the theme which weaves through the nature study. This is not a social approach but one of the recognition of man's place in the order of nature, his rational use and control of the power given him, and the need for further research in this storehouse of knowledge which is the universe.

Having set forth the general ideas upon which the Saint Xavier Nature Study program is based we might, by way of summary, contrast some generally accepted ideas of elementary science with what we mean by nature study.

By definition science is concerned with demonstration from first principles, with a systematic knowledge of causes and reasons for things. We hold that such knowledge is often beyond the level of development of the child. Nature study takes the form of what is often referred to as natural history. It attempts to give the child knowledge and understandings upon which later scientific studies may build.

Modern programs in elementary science are concerned with social and scientific attitudes to be acquired. By stimulating an atmosphere of scientific research, the child often acquires an attitude of self-achievement of all that is to be known on a subject with a loss of interest in a future study of it. Nature study, while recognizing and fostering social attitudes places more value on the development of appreciation, reverence, and humility. Humility of the sort which enables the child to see what he has learned is a small part of what the scientist spends a lifetime in learning.

Both make use of personal experience. In elementary science more emphasis is placed on experimental, while nature study emphasizes sensory experience. The first leans heavily upon the mechanical, the second on the natural. Scientific principles are sought to explain observed phenomena in elementary science, but observation to explain the nature of the thing is the object of nature study.

Elementary science stresses the scientific method as essential from the first stages of learning, often sacrificing meaning to method.

Nature study stresses meanings and understandings without overlooking the value of problem solving. In arithmetic, unless the child knows the meanings of numbers and their relations and processes, he cannot solve arithmetic problems. This emphasis on meaning is equally important in science.

Both aim to discover cause and effect relations, but science seeks only proximate and immediate causes, while nature study goes beyond these to the ultimate cause. Ordinarily science places much faith in theories, often teaching them as facts; we avoid the teaching of such theories, but where an explanation is needed, it is given in simple terms and where no certain explanation is known, this fact is admitted.

Sometimes science, by over-emphasis on the modern and future scientific discoveries, ignores or looks down on the so-called ignorance of earlier ages. Through the study of the history of the achievement of the human race, at the several stages of development, we hope to foster a respect for the contributions of the past to our modern and future discoveries.

Too often the trend in elementary science education today is to press the child onward beyond his level of maturation hoping thus to produce scientists. Our nature study program orders the content to the level of ability and development of the child, aiming to produce an intelligent person capable of thinking critically and judging rightly in his environment. With such a foundation, later scientific studies might well be conceived as an attractive goal to the student who may go on eagerly to become the scientist the world is calling for.

ONE-TON SPACE CAPSULE MAY HOIST MAN 225 MILES

A 2,500-pound, 10-foot capsule forms the chief unit of a new system intended to launch a man into space and recover him safely.

The system, developed by Northrop Aircraft, Inc., as project BROOM (Ballistic Recovery of Orbiting Man) and described to the Institute of the Aeronautical Sciences meeting can utilize existing boosters, available sub-systems and currently known materials and processes.

The BROOM launching system is comprised of a two-stage liquid rocket with a third-stage solid propellant rocket and a small fourth-stage vernier rocket. All are existing units and would have a total launch weight of 267,000 pounds.

The launch system is capable of putting a 2,500-pound capsule into an orbital altitude of 400 nautical miles.

In addition to being 10 feet long, the cone-shaped capsule has a diameter of 89 inches and terminates in a 20-inch spherical radius. A pressurized pilot's compartment contains an air conditioning unit, the pilot's instrument display and control consoles, an astro tracker, and an earth-viewing telescope.

The pilot's seat is in a fixed position contoured for maximum acceleration tolerance. The pilot sits in a semireclined position with his knees flexed, so that accelerations will be applied from chest to back.

Is an Infinitesimal Asteroid as Large as a Colossal Planet? A Mathematical Paradox

Panos D. Bardis

Albion College, Albion, Michigan

Imagine two spherical celestial bodies, a Lilliputian asteroid with a diameter of .0005 mile and a gigantic planet with a diameter of 500,000 miles. To each sphere, attach a ring equal to its equator, to which the metal circle should be affixed concentrically and in the same plane. Then increase the length of each ring by one foot, without disturbing the concentric and same-plane relations. This addition increases the radius of the asteroid's ring by X and that of the planet's by X'. Despite the fantastic difference between these celestial spheres, you will find that the two radii have increased equally!

Here is the evidence:

Given:

Asteroid's (and its original ring's) radius: r.
Asteroid's (and length of its original ring) equator: $2r\pi$.
Radius of asteroid's new ring: $r+X$.
Length of asteroid's new ring: $2r\pi+1$ foot.

To prove:

$$X=X'.$$

Proof:

$$r+X=\frac{2r\pi+1 \text{ foot}}{2\pi}.$$

$$X=\frac{2r\pi+1 \text{ foot}}{2\pi}-r.$$

$$X=\frac{2r\pi+1 \text{ foot}}{2\pi}-\frac{2r\pi}{2\pi}.$$

$$X=\frac{2r\pi+1 \text{ foot}-2r\pi}{2\pi}.$$

$$X=\frac{1 \text{ foot}}{2\pi}.$$

If, in the above data and calculations, we substitute "planet" for "asteroid," r' for r, and X' for X, we obtain

$$X'=\frac{1 \text{ foot}}{2\pi}.$$

Therefore,

$$X = X'.$$

SEAT BELT CUTS MORTALITY

Riding in your car with a seat belt strapped around you can spell the difference between life and death. A person's chances of surviving a serious accident are far greater when he is not thrown from the car. Studies show that the risk of death to occupants who are thrown from the car is about five times as great as those who remain inside the car.

The Origins of High School General Biology[1]

Sidney Rosen

College of Education, University of Illinois, Urbana, Illinois

The high school general biology course is historically interesting because it marks the first successful revolt by high school science teachers against the domination of biology course content and methods by college professors. General biology came into vogue during the third decade of the twentieth century; its coming heralded the demise of the specialized courses in botany, zoology, and physiology. Today, general biology is elected by more students at the senior high school level than any other science.

Strangely enough, the specialized courses in botany, zoology, and physiology emerged from a kind of general biology course known as "natural history." This course usually covered all in nature that could be filed under any one of the three fundamental categories: animal, vegetable, or mineral. Since the teaching of natural history was largely descriptive, schools sought to acquire adequate "cabinets," or collections (kept in flat cabinet drawers) of minerals, plants, and preserved animals.

As in the case of high school geography, the influence of the German universities metamorphosed natural history into the three specialized areas mentioned above. Geography, however, never recovered from its dissection by the specialists.[2] The emergence of the high school general biology course was one of the great victories of general over specialized education.

Early Biology Courses

In 1821, the original curriculum of the first American high school, the English Classical School in Boston, Mass., listed a course taught in all three classes: *Elements of Arts and Sciences*. The textbook for this course was Blair's *The Universal Preceptor*, a "general grammar of arts, science, and useful knowledge." Amid such varied subject matter as metallurgy, navigation, geography, astronomy, chemistry, electricity and galvanism, magnetism, optics, meteorology, physics, mythology, heraldry, literature, and morals and religion, there were 13 pages devoted to botany ("Of Vegetable Nature") and 31 pages devoted to zoology ("Of Animated Nature").

Into this small space were crammed descriptive facts, classifications, a few drawings of plants and animals, (see Fig. 1) and many poetic quotations. The latter served to point up the wonderful har-

[1] Adapted and modified from a doctoral dissertation, "A History of Science Teaching in the American High School, 1820–1920," Harvard University, 1955.

[2] See: S. Rosen, *Journal of Geography*, LVI, 9, 405–413 (1957).

mony of nature and its relation to moral behavior; for example:

"Insects, viewed through a microscope, would teach children to respect their lives and happiness, and never, in wantoness, to destroy the most apparently insignificant. The child who treads upon a worm, or destroys a fly in sport, gives indication of a wicked, cruel, or thoughtless mind.

'The poor beetle, that we tread upon
In corporal suff'rance, feels just as great a pang
As when the giant dies.' Shakespeare."

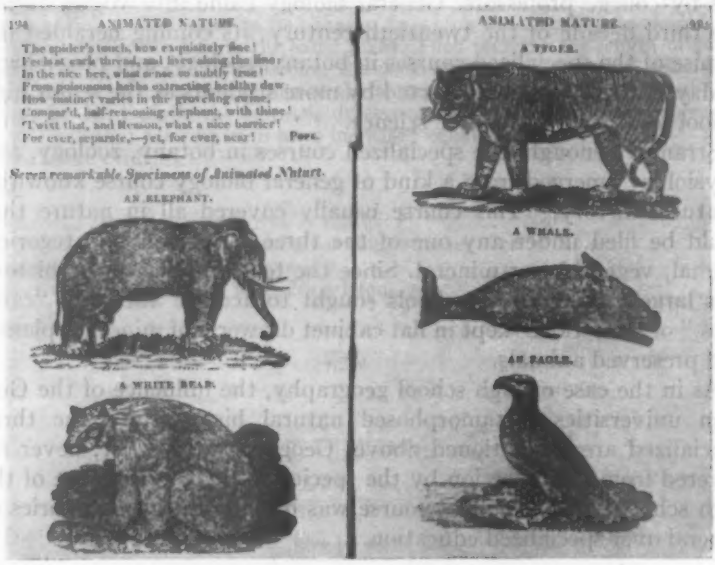

194 ANIMATED NATURE.
The spider's touch, how exquisitely fine!
Feels at each thread, and lives along the line:
In the nice bee, what sense so subtly true!
From poisonous herbs extracting healthy dew;
How instinct varies in the grovelling swine,
Compar'd, half-reasoning elephant, with thine!
'Twixt that, and Reason, what a nice barrier!
For ever, separate,—yet, for ever, near!
Pope.
Seven remarkable Specimens of Animated Nature.
AN ELEPHANT.
A WHITE BEAR.
ANIMATED NATURE. 195
A TIGER.
A WHALE.
AN EAGLE.

FIG. 1. The zoological illustrations in Blair's *Preceptor*.

In 1825, when the Classical School had moved to Pinckney Street and had become the English High School, a course in the "Philosophy of Natural History" was offered to third-year students (along with chemistry, intellectual philosophy, linear drawing, and logic). After this time, natural history courses began to appear in the curricula of other high schools in the east. In some large city schools, the course was taught (along with comparative anatomy) by a physician. In 1840, the new Central High School in Philadelphia appointed Dr. H. McMurtrie as Professor of Natural History. His courses covered "general principles of special physics. Bony, muscular, vascular, and nervous systems, etc. Evidences of design. Applications to the ordinary cases of bodily injuries."

Probably the most popular textbook used in early natural history courses was William Smellie's *The Philosophy of Natural History*, published in England in 1790, and first published in America the following year by P. Campbell of Philadelphia. In 1824, the book was

edited and partly rewritten by a physician, Dr. John Ware, who added new discoveries in physiology and allied fields. Smellie, in true encyclopedic fashion, included much of the curiosities of antiquity, quoting abundantly from Pliny, Herodotus, Pontoppidar, and others. Nevertheless, this book remained as a popular secondary school textbook until the Civil War; a new edition appeared as late as 1867.

The zoological aspects of natural history in early courses were treated primarily from two aspects: (1) curiosa and anecdotes, and (2) moral and religious significance. Smellie, in his preface, pointed out that his text was designed to "exhalt the glory of God through the wonders of nature," and the knowledge acquired by the student would be "a perpetual and inexhaustible source of many pleasures; it [would] afford innocent and virtuous amusement, and [would] occupy agreeably the leisure or vacant hours of life."

As a high school subject, natural history did not seem to be considered fundamental to the secondary school curriculum. When public examinations of pupils were held in the high schools, as was the custom in the common school system, natural history was usually omitted. At the public examination held at the Cambridge, Mass., High School in 1856, for example, questions were asked only in the following subjects: geography, geometry, algebra, and natural philosophy.

In general, the proponents of the teaching of natural history had to combat an *a priori* attitude about the uselessness of the subject. Marion R. Brown, who traced the development of zoology teaching in America up to the turn of the century,[3] noted that "public and common schools excluded it entirely from their curricula. The cause of this was the mistaken idea prevalent in so many communities of its inutility. It was looked upon as an accomplishment inapplicable to the sterner duties of life. . . . "

Eventually, however, the specialized areas of biology began to appear as separate courses in the curricula of American high schools. Of these, perhaps the earliest was botany.

Rise and Fall of High School Botany

The first high school course in botany seems to have been offered in 1826 at the short-lived Girls' High School in Boston. The kind of botany taught in early courses was primarily descriptive and pleasant, concerned with the recognition and classification of plants. The subject was considered a "delightful occupation for the youthful mind," a promoter of mental improvement, and "admirably adapted to the tastes, feelings, and capacities of females."

This latter correlation between botany and femininity restricted

[3] M. R. Brown, *School Science*, II, 4, 202 (1902).

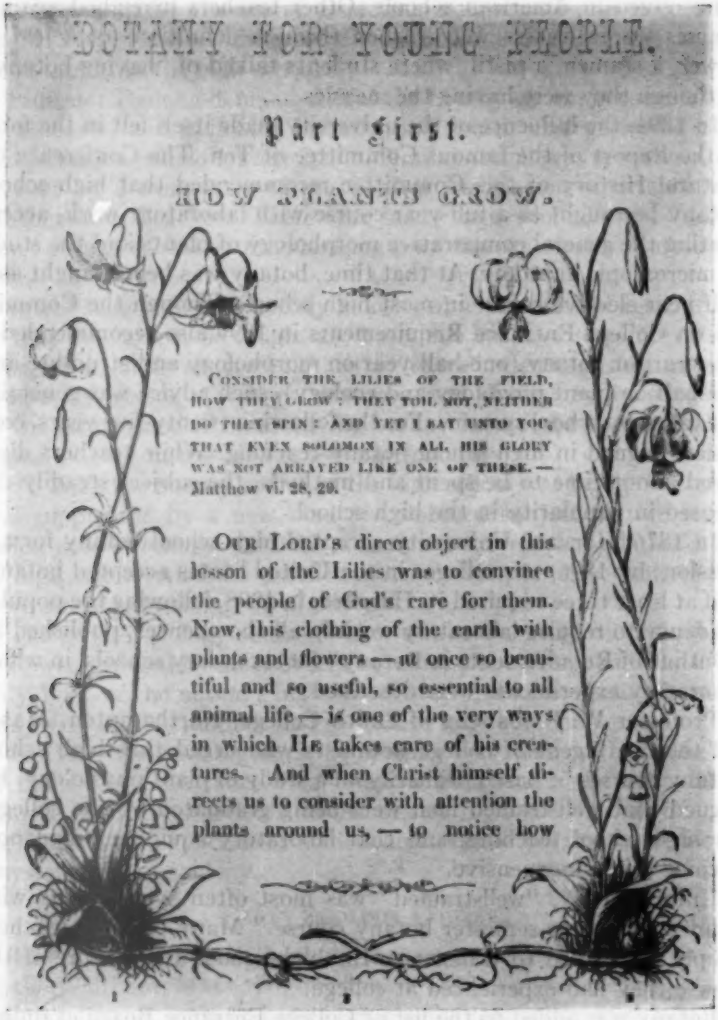
the number of high school students electing this science. By 1887, this limitation had begun to alarm botanists. In that year, a Dr. Adams wrote in the January issue of *The Swiss Cross* (the publication of the Agassiz Association): "An idea seems to exist in the minds of some young men that botany is not a manly study; that it is merely one of the ornamental branches, suitable for young ladies and effeminate youths, but not adapted for able-bodied and vigorous-brained young men who wish to make the best of their powers."

The Massachusetts law of 1857 required botany to be taught in high schools of towns with 5000 families or over (after 1898, the teaching of botany in such schools became permissive). However, there is evidence that many schools systems failed to live up to such a requirement.

Perhaps the most popular early textbook in botany was *Elements of Botany*, by Dr. W. S. W. Ruschenberger, a Navy surgeon. This was one of a series of eight "First Books in Natural History" by his author, and was first published in Philadelphia in 1844. The other books covered anatomy and physiology, mammalogy, ornithology, herpetology and ichthyology, conchology, entomology, and geology. *Elements of Botany* was an adapted translation of a French botany text written by Mile and Comte of the Collège de Henri IV et Charlemagne. Ruschenberger followed the catechetical style of the period; using his book, anyone could teach botany.

The most famous American scientist associated with the teaching of botany during mid-nineteenth century and after was Asa Gray (1810–1888). Appointed professor of natural history at Harvard University in 1842, Gray was a pioneer in plant geography, and, after 1857, the chief advocate of Darwinism in America. His textbook series called "Botany for Young People and Common Schools," begun in 1858, were most influential in popularizing descriptive botany. The three books of this series, *How Plants Grow*, *How Plants Behave*, and *Lessons in Botany*, were used most widely in high school courses. These books were beautifully illustrated, and their texts easy and flowing (see Fig. 2). Included in *How Plants Grow* were clear and simple directions for gathering, examining, keeping, and classifying botanical specimens. Because of Gray's influence, systematic and descriptive botany became the avocation of many people. Circles of nature lovers were formed, and many valuable collections of plants were acquired.

By the last decade of the 19th century, changes in the teaching of botany mirrored the changes in the science itself. Darwin's work centered attention on the structure and growth processes of plants. Researchers in the colleges became interested in the plant as an organ-



BOTANY FOR YOUNG PEOPLE.

Part First.

HOW PLANTS GROW.

CONSIDER THE LILIES OF THE FIELD, HOW THEY GROW: THEY TOIL NOT, NEITHER DO THEY SPIN: AND YET I SAY UNTO YOU, THAT EVEN SOLOMON IN ALL HIS GLORY WAS NOT ARRAYED LIKE ONE OF THESE. — Matthew vi. 28, 29.

OUR LORD'S direct object in this lesson of the Lilies was to convince the people of God's care for them. Now, this clothing of the earth with plants and flowers — at once so beautiful and so useful, so essential to all animal life — is one of the very ways in which HE takes care of his creatures. And when Christ himself directs us to consider with attention the plants around us, — to notice how

FIG. 2. The first page of Asa Gray's famous book. Note the reverent attitude toward the religious implications of science.

ism. New specialized areas of study appeared: plant ecology, plant physiology, plant pathology, and genetics.

The secondary school course based upon Gray's work remained in the schools, while the new emphasis on morphology, physiology and laboratory work appeared in the universities. As late as 1891, a botanist complained about the "time-honored course in botany" still

being given in American schools. Other teachers inveighed against courses where classes were rushed through definitions of a leaf, a flower, a stamen, a pistil; where students talked of "having botany" as though they were having the measles.

In 1894, the influence of the university made itself felt in the form of the Report of the famous Committee of Ten. The Conference on Natural History of this Committee recommended that high school botany be taught as a full-year course with laboratory work, accentuating the general comparative morphology of plants and the study of microscopic anatomy. At that time, botany was being taught as a half-year elective course in most high schools. Though the Committee on College Entrance Requirements in 1899 also recommended a full year for botany (one-half year on morphology and structure and one-half on plant phyiology and ecology), such advice was generally not taken by school systems. For the following twenty-five years, confusion reigned in high school botany teaching. While teachers disagreed about time to be spent and methods, the subject steadily decreased in popularity in the high school.

In 1876, Harvard University accepted high school botany for admission; by 1896, ten colleges in the United States accepted botany, and at least three required it. Harvard, in 1898, following the popular tendency to require laboratory work in all the sciences, published an "Outline of Requirements in Botany" for secondary schools, in which laboratory experiments were described.

Professor W. F. Ganong of Smith College, Northampton, Mass., led the contingent of college botanists who urged that high school botany courses be based primarily on a study of plant physiology. He argued that well-trained men were being graduated by the colleges for high school teaching, and that laboratory equipment had now become fairly inexpensive.

Unfortunately, "well-trained" was most often synonymous with "had taken a one-semester botany course." Many of these teachers simply attempted to transfer to the high school a miniature of the course they had experienced at college.

Botany was added to the list of College Entrance Board examinations in 1902. The first examination paper followed the suggestions of the Committee of Ten, covering: plant anatomy and morphology, plant physiology, plant ecology, natural history of plant groups, and classification.

As in the case of the other sciences,[4] the teaching of botany by the turn of the century had swung toward the extremes of the laboratory method. Descriptive botany disappeared; in its place appeared a

[4] See: S. Rosen, *Am. Journal of Physics*, 22, 194–204 (1954) and *Journal of Chem. Education*, 33, 627–633 (1956).

botany taught by the use of dissecting instruments and the microscope. Yet, educators disagreed about the kind of botany that ought to be taught in the high schools.

Professor Ganong demanded that the botany course become a full-year course, and indicated in 1903 that Smith College would only accept such a course for admission. Similar action was recommended in 1905 by a committee of the Central Association of Science and Mathematics Teachers. There were many suggestions for the "salvation" of high school botany, ranging from the practical to the ridiculous.

It was suggested that botany be merged with practical agriculture, or that the subject be taught as "economic botany." One university botanist seriously suggested that the "extra" sciences, as astronomy, geography, geology, zoology, anatomy, and physiology, be relegated to the elementary schools, leaving botany as the one important biological science in the high school curriculum!

By 1920, the botany course in the high school was being overtaken and supplanted by a new kind of combined subject matter course called *general biology*. In 1922, a national survey showed that 3.8% of high school students enrolled were electing botany, while 8.8% were already electing general biology.

The general biology course (which will be discussed more fully below) was opposed by most college botanists, but to no avail. By 1928, only 1.6% of the nation's high school students were electing botany, and by 1934, this number had shrunk to less than one percent.

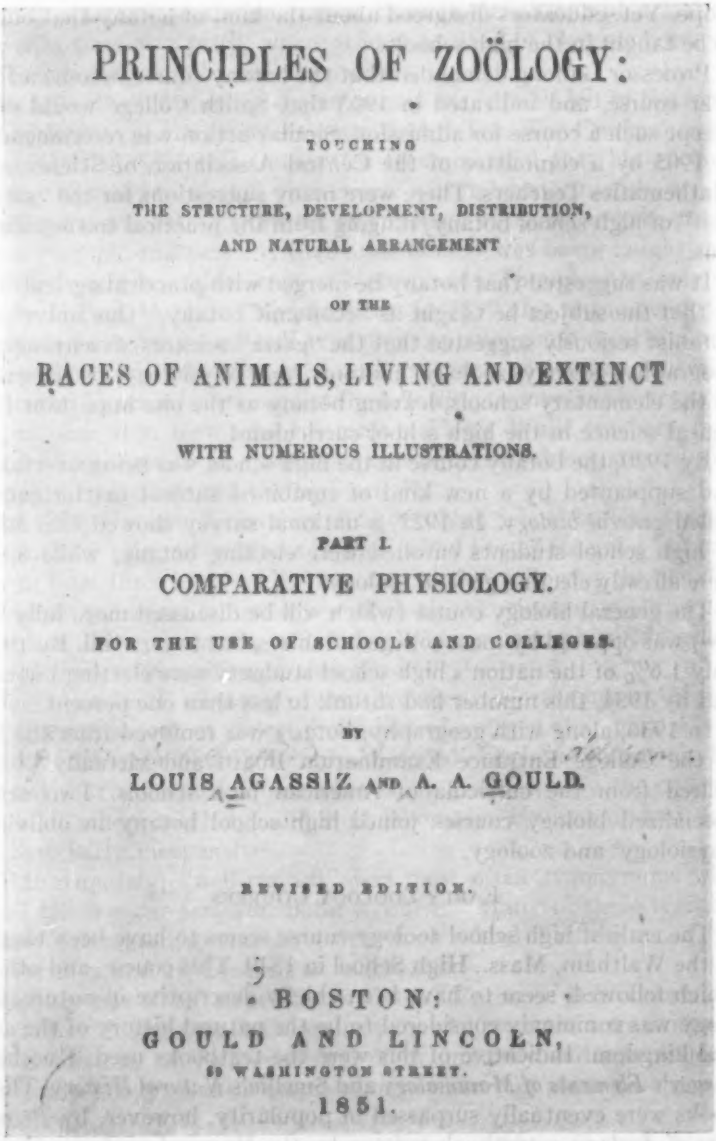
In 1936, along with geography, botany was removed from the list of the College Entrance Examination Board and virtually disappeared from the curricula of American high schools. Two other specialized biology courses joined high school botany in oblivion: physiology[5] and zoology.

Early Zoology Courses

The earliest high school zoology course seems to have been taught at the Waltham, Mass., High School in 1849. This course, and others which followed, seem to have been chiefly descriptive in nature; zoology was commonly considered to be the natural history of the animal kingdom. Indicative of this were the textbooks used: Ruschenberger's *Elements of Mammalogy* and Smellie's *Natural History*. These books were eventually surpassed in popularity, however, by *Principles of Zoology*, a textbook written by the Harvard professor, Louis Agassiz, in collaboration with his assistant, A. A. Gould (see Fig. 3).

Born in Switzerland in 1807, Agassiz came to America to accept a professorship in zoology and geology at Harvard in 1848, a position

[5] See: S. Rosen, *School & Society*, 85, 2118, 308–311 (1957).



PRINCIPLES OF ZOÖLOGY:

TOUCHING

THE STRUCTURE, DEVELOPMENT, DISTRIBUTION,

AND NATURAL ARRANGEMENT

OF THE

RACES OF ANIMALS, LIVING AND EXTINCT

WITH NUMEROUS ILLUSTRATIONS.

PART I.

COMPARATIVE PHYSIOLOGY.

FOR THE USE OF SCHOOLS AND COLLEGES.

BY

LOUIS AGASSIZ AND A. A. GOULD.

REVISED EDITION.

BOSTON:

GOULD AND LINCOLN,

59 WASHINGTON STREET.

1851.

FIG. 3. The title page of Agassiz' textbook—the book that brought high school zoology into its own.

he held until his death in 1873. He became famous as a dynamic lecturer both in and out of the University, and showed unusual interest in the teaching of secondary school science. Eldridge Smith, the first headmaster of the Cambridge High School, recalled the arrival of Agassiz: "He offered to lecture gratuitously every week in the high school upon natural history. The offer was gratefully accepted. . . . His remarkable ability at the blackboard, his intense earnestness, his whole soul beaming from the eye and glowing in every feature were quite a new revelation to an American audience."

In 1859, Agassiz made another unprecedented move in science education by throwing the doors of his laboratory open to any high school teacher who wanted to learn more zoology. Fourteen years later, in 1873, he established the famous summer school of marine biology at Penekese Island; from here, many inspired young teachers went out to teach the methods of Agassiz in secondary schools.

There is no doubt that Louis Agassiz transformed zoology from a rather ordinary descriptive course into a vital and exciting discipline. A. S. Packard, one of his students whose manual of comparative anatomy achieved fame about 1880, said of Agassiz: " . . . more than anyone else he should be credited with the revolution in teaching: *i.e.*, laboratory work *vs.* book work, or learning lessons by memory. He was thus a reformer, infusing an independent spirit in his pupils. From a study of stuffed birds and dried insects, zoology became a disciplinary, broadening, and philosophical study."

Another popular zoology textbook, published in 1866, was Sanborn Tenney's *Natural History*. This well-illustrated book, however, followed the traditional pattern of description and classification. Though Darwin had already published his *Origin of Species* in 1859, there was no great hue and cry by American zoologists and botanists (except for Asa Gray) to discredit previous concepts. It was a time when the theory of spontaneous generation of life was still being seriously considered by reputable scientists.

The first textbook written for high school students which departed expressly from the previous compendia of animal life from man to protozoa was the *First Book of Zoology* by Edward Sylvester Morse, who had studied under Agassiz. This book, published in 1875, laid emphasis on the lower animals (hitherto generally neglected) and included directions for learning the haunts of these animals, collecting specimens, and preparing them for the cabinet. Morse's simple and beautiful line drawings (he also illustrated Tenney's book) are still considered masterpieces of textbook art (see Fig. 4). Morse sought a way to interest the high school student in the simple forms of life which could be collected at the seashore, or found near a fence, or an old barn.

holding the chrysalis horizontally, or vertically, against the fence, as in Fig. 80, *C*.

Some of them are encased in a mesh of threads, which may be built against the fence, or under the edges of clapboards on the sides of houses. And within the cocoons collected, the chrysalides, or their empty cases, will be found, as in Fig. 73.

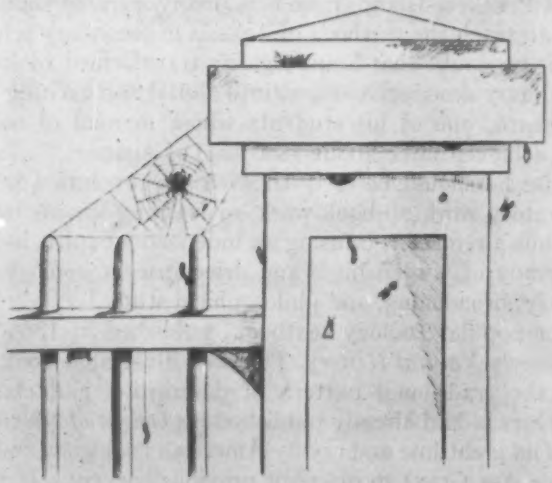


FIG. 73.—PORTION OF A FENCE, HAVING UPON IT, AMONG OTHER THINGS, EGGS, CATERPILLARS AND CHRYSALIDES OF INSECTS.

Rich collecting-places may always be found on old garden-fences in cities and towns. Fences surrounded by trees and bushes will oftentimes have a great many insects lurking under projecting edges—caterpillars climbing up the posts,

FIG. 4. A page from E. S. Morse's *A First Book of Zoology*, showing the beautiful, simple line drawings that were so appealing to children.

The Impact of Darwinism

Many American scientists (Agassiz was one) refused to accept Darwin's radical theory of natural selection and evolution. The firm grip of deep religious convictions made such ideas anathema to these men. In America, the conflict between evolution and supernaturalism "threatened to take from the faithful all sense of security just when security was desperately needed in a civilization rapidly shifting from a rural to an industrial and urban basis."[6]

The effect of Darwinism on high school zoology was relatively indirect, and was hardly as striking as had been the influence of Agassiz and his students. Two possible reasons for this are: (1) the methods of Agassiz, as popularized by Morse, were far more suited to the high school level, and (2) the immediate impact of Darwinism was on the European schools and scientists, an ocean away. Actually, evolution was not taught directly in American high schools until after 1900. The controversy culminated with the well-known Scopes trial in 1925.

Darwin's ideas, however, were implicit in the textbook that came from England to American in 1875 to change the direction of zoology teaching in the colleges and universities: *A Course of Practical Instruction in Elementary Biology*, by Thomas Huxley and Henry Martin. The subject matter was comparative anatomy; the method, dissection in the laboratory. For Huxley, as stated in his preface, the only way to achieve competency in zoology was to study morphology and physiology by means of practical laboratory work. The textbook was a laboratory guide which placed the student in the position of a verifier; for example: " . . . pass a bristle into one of the anterior nares [of the frog] . . . if the bristles have been thrust far enough . . . the former will be seen traversing the posterior nasal opening. . . . "

Those college students who went out to teach high school zoology tended to repeat the instruction they had experienced, the laboratory instruction of Huxley and Martin. By the 1880's, the very textbooks used in the colleges began to be used in high school laboratories. In 1886 came the first zoology laboratory manual prepared expressly for the high school: *An Elementary Course in Practical Zoology*, by Buel P. Colton. It is interesting that Colton, in the preface to his book, urged school boards to lighten the teaching loads of high school zoology teachers, so that they might have sufficient time to prepare their laboratory sessions properly.

The report of the Conference on Natural History of the Committee of Ten in 1894 recommended a full year for high school zoology, as well as botany, with emphasis on laboratory work in microscopic an-

[6] Merle Curti, *The Growth of American Thought*, N. Y., Harper (1943), p. 549.

atomy. By this time, however, most high schools were offering a one-year course in biology, consisting of a half year each of botany and zoology.

Supply of Zoology Teachers

After the Civil War, the problem of getting teachers with adequate backgrounds in zoology was a serious one for most American high schools. This lack of qualified teachers became apparent in a spectacular way when states began passing laws concerning curriculum requirements at the secondary level. In Illinois, for example, the requirement, by the law of 1872, of the passing of examinations in zoology (as well as physiology, botany, and chemistry) for high school teachers gave rise to many cramming schemes. *The Illinois Schoolmaster* published outline lessons in these subjects, virtually guaranteeing that anyone memorizing their lessons would pass the required examinations with ease.

Between July 1 and October 1, 1872, 3114 teachers out of 3875 in Illinois passed the qualifying examinations in secondary school science. Quite often, these examinations were administered orally by a school administrator. It is not amiss to repeat here the story of the young lady who was asked by an Illinois school superintendent to classify the turtle. "It is a crustacean," she said (probably thinking of pie crust—two layers with filling in between). "No," said the examiner, "it's a mollusk, because it has a shell!" Rumor had it that the lady received her teaching certificate nevertheless.

During the decade, 1880–1890, there did not seem to be a dearth of zoology teachers in the high schools, particularly in those of the large urban centers. This contrasted vividly with the scarcity of qualified chemistry and physics teachers in the same schools. It may be assumed that since there was no real economic demand for specialized biological training in industry at this time, biology majors in college could apply their studies by going into medicine, becoming researchers and teachers at the college level, or teaching in secondary schools. Also, many of the top-flight normal schools, as the Illinois State Normal School, had excellent programs in the preparation of biology teachers for the high schools.

The majority of high school zoology teachers at the end of the 19th century were probably teaching a carbon copy of the elementary college course. This may well explain the rapid influx of Huxley's laboratory method of teaching into the American secondary school—a *fait accompli* by 1890.

Breakdown of the Standard Zoology Course

In 1898, Harvard University signalled a readiness to accept high school zoology for admission, requiring, as had been the case with

chemistry and physics, laboratory work by the high school student. The *Outline of Requirements* published by Harvard indicated that the student had to pass both a written and laboratory examination in zoology, besides presenting a notebook containing the notes and drawings made in the high school zoology laboratory.

The Harvard Outline, written by Charles B. Davenport, professor of zoology, emphasized experiments upon *living* animals and marked a kind of return to the old idea of natural history as the proper content of high school zoology courses. In 1900, Davenport, collaborating with his wife, developed this idea further with the publication of his textbook, *Introduction to Zoology*. In the introduction, he stated:

> "The general plan of this textbook is at the same time both old and new. Old' because it attempts to restore the old-time instruction in Natural History; new, because Natural History is not today what it was a generation ago. The treatment will also seem new in contrast with modern textbooks of zoology, since they are devoted to comparative anatomy, a field upon which we lay little stress . . . the ordinary citizen . . . wants to know where else over the world, the common animals of his state are to be found, and as a legislator or as a taxpayer, he wants to know how animals affect man. It is more important for him to know these matters than to know the location of the pedal ganglion of the snail . . . ."[7]

Davenport's attitude was unusual and bold for a college specialist. At this time, only certain high school teachers were beginning to recognize that the high school might have other possible aims than the supplying of students for the colleges. Davenport's influence was strong enough to influence the writing of the first College Entrance Examination Board examination in zoology; questions on natural history were included in a test based primarily on the Huxley laboratory method of teaching. The Board had been asked, in 1905, to establish an examination in this special area; however, because of the confusion among zoology teachers as to how much and what kind of zoology should be taught, requirements were not established until the following year. In 1906, seven high school students in the entire country took the first zoology College Board examination.

After Davenport, different aspects of zoology began to be emphasized by textbook writers, in an effort to "humanize" the laboratory method course. In 1907, the publication of Jordan and Kellogg's *Animal Life* brought in ecology, the relation of animals to their surroundings, as the central theme of a zoology course. Nevertheless, it had already become apparent by this time that high school zoology was slipping in popularity. In 1909, more high school pupils selected physics and chemistry than zoology.

High school zoology never achieved the status of being required for college admission, but was acceptable by most colleges after the

[7] C. B. & G. B. Davenport, *Introduction to Zoology*, N. Y., Macmillan (1900) Preface.

appearance of the first College Board examination (only five colleges in the country were accepting zoology for credit in 1898). A Federal survey in 1922 showed that only 1.5% of the nation's high school pupils were electing zoology. By 1928, this percentage was halved. In 1936, zoology was wiped off the books of the College Entrance Examination Board and became a subject of relatively minor occurrence in high school curricula.

The Rise of General Biology

During the period 1905–1910, an undercurrent of dissatisfaction with course content and laboratory work appeared among high school teachers of botany, physiology, and zoology. It was a time when there seemed to be little agreement among teachers as to what should be taught in high school biology courses.

The newly important function of the high school as a training ground for those pupils who left it to go out into the world of business and industry brought an appeal for a course that would give youth a better understanding of its position in nature. Other educators pleaded for a college preparatory course that related biology to human culture, scientific method, and the living world. At the other end of the spectrum were the die-hards who insisted that the Huxley kind of comparative anatomy and morphology courses were the only fruitful ones.

In 1907, the Education Section of the American Association for the Advancement of Science issued a plea for a high school biology course based entirely on the natural history viewpoint. At the same time, the Central Association of Science and Mathematics Teachers lent its support to a senior year biology course based upon and preceded by strong courses in physics, chemistry, plant physiology, and animal physiology. There seemed to be, among biology teachers, a clamor for the teaching of morphology, physiology, ecology, taxonomy, natural history, general biology, economic biology, individual biology, and agricultural biology.

In 1907, there also occurred a discussion on a proposed new biology course at a meeting of the New York Association of Biology Teachers. Rather than include abstract principles along with laboratory work in morphology and histology, this course dealt with living things and their social and economic importance. Such a course, it was indicated, had three major values: it would imbue the student with proper habits of thought, cultural value, and practical utility. Two years later, in 1909, the transformation to this kind of general course began in the high schools of New York City. Known as *General Biology*, the course emphasized man in his biological environment.

High school teachers did not accept readily the centering of a

biology course about man. It was argued that a course which divided all biological knowledge into two categories—all that was useful or harmful to man—would give the impression that biological science was important only to the needs of man. Nevertheless, the proponents of general biology recognized two immediate goals: (1) relief of the congested high school curriculum, with its hopeless mass of diversified sciences (physics, chemistry, physiology, zoology, botany, physiography, astronomy, meteorology, geology); (2) unification that would lead to an equal footing with physics and chemistry in the high school curriculum.

In 1910, the New York State Board of Education published a general biology syllabus which became a kind of fugleman for proponents of the course. Four major aims were stated for general biology: (1) to give boys and girls a first-hand knowledge of some common plants and animals; (2) to lead pupils to some understanding of the essential functions carried on by all living things; (3) to teach them something about the enormous economic importance to man of plant and animal products and the necessity of preserving the biological resources of the country; and (4) to emphasize especially the essential conditions of individual and public health in city and state. In many ways, the introduction of general biology was a reaffirmation of high school teachers of Pestalozzi's ideology, now welded to the pragmatism of John Dewey.

Interest in general biology heightened and spread to other parts of the United States. By 1913, the acceptance of this course had become universal enough to make the subject acceptable for admission to colleges. At their November meeting in that year, the College Entrance Examination Board voted to hold an examination in biology the following June based upon combined half-year courses in botany and zoology. Though this description implied recognition of the standard specialized courses, the concession toward an all-inclusive title—*biology*—was the first step toward the inclusion of a general biology examination. Twelve high school students took this examination in 1914.

General biology met with particular favor in the midwest. In this area, with its predominance of rural students, the course was considered "functional." In contrast, New England professors of zoology tended to be unhappy about the new course. In 1916, Professor Herbert E. Walter of Brown University wrote, "At the present time, it is frequently true that the biological course of the average high school has a strong resemblance to hash. To speak plainly, it too often consists of warmed up left-overs, *e.g.*, a little nature study from the grades, some large indigestible chunks of college zoology, a dash of elementary physics and chemistry, a little botany and hygiene,

and in certain states where required by law, an intemperate dose of temperance."[8]

The coming of World War I served to increase a tendency toward "practicality" in the teaching of general biology. There were economic values to be discussed in biology which concerned the defeat of Germany by starvation; this was economic biology. And the social values of an industrious and patriotic society could be learned by watching ant colonies at work! A popular textbook in use at this time was G. W. Hunter's *A Civic Biology*, in which the author tried "to recognize the interests [of children] and [to] adapt the content of [his] course in biology to the immediate world of the pupil."

The revolt of high school biology teachers against the formalism imposed upon biology teaching by university professors increased in intensity up to and beyond 1920. The transfer to the high school of college teaching and laboratory techniques was denounced as archaic, ruinous, and contributory to the decline of interest on the part of the student in high school botany and zoology. Statistics seemed to support this point of view. While the total high school population rose from 739,143 in 1910 to 1,165,495 in 1915, the total enrollment in botany courses dropped from 116,497 to 106,520—15.8% to 9.1%! In zoology, the drop was even greater: 51,370 to 37,456—6.9% to 3.2%! Physiology, too, dropped from a total enrollment of 142,401 in 1900 to 116,541 in 1915—27.4% to 9.5%!

General biology grew fat at the expense of these losses. From 7883 in 1910, total enrollment in high school general biology increased to 80,403 in 1915—1.1% to 6.9%! By 1949, general biology had virtually displaced all other specialized courses. Out of a total high school population of 5,389,452 in the United States, 995,930 (18.4%) were electing general biology, while enrollments in botany and zoology had fallen to a pitiful 0.1%.

General biology occurred most frequently in the tenth grade, or the first year of the three-year high school course. For small high schools, general biology provided greater economy of time and teaching staff. The scope of general biology was broader, less technical, and more practical. In short, the new course was far better adapted to the American high school than botany and zoology courses.

After the action by the College Entrance Examination Board in 1913, Harvard University accepted the "biology" examination as equal to credit for a half semester each of botany and zoology. In 1918, Harvard added admission credit for a full year of general biology as apart from botany and zoology. When the College Board dropped the specialized subject examinations in 1936, Harvard again

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[8] H. E. Walter, School Science and Mathematics, IX, 8, 721 (1909).

followed suit: general biology remained as the only acceptable biology course for admission in the Harvard catalog.

Despite a widespread opinion that general biology was a poorly organized, incomplete, snap course in the hands of incompetent teachers, the new experiment in high school science teaching attracted students. In the smaller schools, general biology was replacing botany, zoology, and physiology; in the larger, it was being added to the curriculum as an elective—but one whose popularity increased alarmingly at the expense of the specialized courses.

By 1936, it appeared that in biology, at least, a panacea for the ills of high school science teaching had been found.

Transient Induced Electromotive Force

Tenth in a Series

Harald C. Jensen

Lake Forest College, Lake Forest, Illinois

Transient currents and voltages play an important part in many electrical circuits and should be called to the attention of even the beginning student of physics. A means of demonstrating a transient electromotive force inexpensively and positively is illustrated in the figures. Figure one is a sketch of the necessary apparatus showing a B-battery B, an inductance L, a neon glow lamp N, and switch S connected according to the circuit in figure two.

When the switch is closed the battery potential difference of 45 volts is applied to the parallel combination consisting of the inductance and the neon lamp. Current grows in the inductance and reaches its final steady state value rapidly. The neon lamp, however, does not glow since more 45 volts are required to ignite it. On the other hand, when the switch is opened the magnetic field of the inductance collapses and in so doing induces an emf across its terminals. The existence of this emf is evidenced by a momentary flash of light in the neon lamp. It is a transient since the lamp only flashes. Furthermore, one knows that it is larger than the battery potential difference. It ignites the lamp while the battery does not.

Note that the lamp flashes when the switch is opened and not when it is closed. This is a dramatic change from the usual. For this reason the apparatus is a desirable one for exhibit use where it is possible for the individual student to close and open the switch at will.

Any 45 volt B-battery[1] is satisfactory. The switch[1] is simply single-pole single-throw. A choke such as those used in power supplies of electronic apparatus[1] can be used for the inductance. The neon glow

[1] Can be obtained from suppliers of electronic apparatus.

lamp[2] must be chosen so that its ignition potential difference is more than the battery potential difference and less than the emf induced by the inductance.

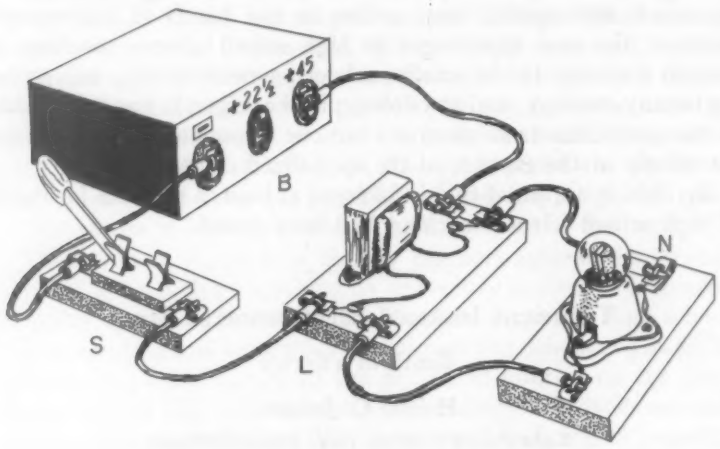

FIG. 1. A sketch showing apparatus useful for producing transient electromotive force.

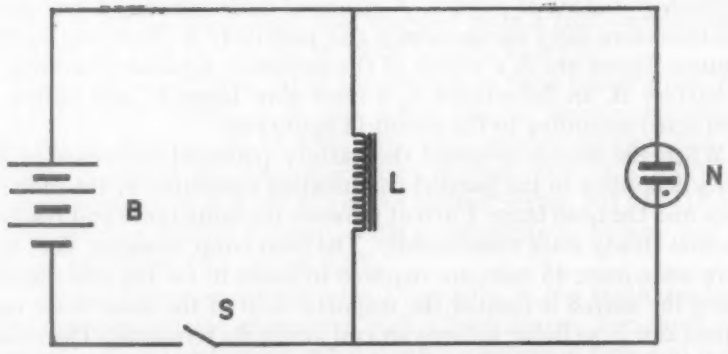

FIG. 2. A schematic diagram of circuit useful for producing transient electromotive force.

[2] Like NE 34; Catalogue #52E805, Allied Radio Corp., 100 N. Western Avenue, Chicago 80, Ill.

LIFE SPAN INCREASES

The average life span of the American wage earner is lengthening. Mortality figures for the year 1958 reveal that the expectation of life at birth increased to 70.2 years for the millions of industrial policyholders of the Metropolitan Life Insurance Company. This represents an increase of 0.2 year over the 1957 figure. The past decade has witnessed an increase of three years in the average length of life of these insured persons, and eight years since 1938.

In the Interests of Conservation . . .

Thomas G. Overmire

Shortridge High School, Indianapolis, Indiana

"Conservation is not a subject, but a point of view."

Paul B. Sears

Conservation is hard to define. To some people conservation means raising pheasants; to some people it means building dams; to some people it means protecting wilderness areas. Being called a conservationist may or may not be a compliment. Some people feel that all conservationists are "bird-lovers"; others suspect that all conservationists are exploiters of the public domain. Conflicting actions taken "in the interests of conservation" are legion. Herein lies a basic problem that should not be neglected when teaching conservation—the problem of conflicting interests.

The section of the country a person lives in may influence the importance that he places on any one phase of the conservation picture. It is hard for someone who lives in the humid East to sense the importance and urgency of the water situation in the West. Likewise, for those who have always lived among the grandeur of the Rocky Mountains it is difficult to comprehend the basis for the fervency of Eastern "protectors of the wilderness" organizations. These differences in viewpoints are bound to precipitate occasional misunderstandings.

Many organizations are directly concerned with conservation problems. Nature study clubs, 4-H clubs, hunting and fishing clubs, arms and ammunition manufacturers, the U. S. Army Corps of Engineers, the National Park Service, the American Forestry Association, petroleum companies—all have vital commitments in conservation. Since each organization has a somewhat different philosophy, it is inevitable that plans and policies will clash occasionally. The Izaak Walton League "in the interests of conservation" (i.e. better fishing) may take a vigorous stand against policies that permit factories to dump industrial wastes into streams. This opinion may differ considerably from that of a local Chamber of Commerce that is more interested in keeping industry content than in keeping streams sparkling pure. The diverging ideas expressed by lumber companies and the National Park Service on the future of the virgin forests in Olympic National Park illustrates another example of this struggle. Unless the teacher points out the presence of these conflicting viewpoints, students may fail to grasp the real significance of the conservation concept.

It is important that students come to realize that many of the actions taken by governmental and private organizations "in the inter-

ests of conservation" are done so without adequate understanding and research.[1] It is equally important that students come to realize that many measures are prompted by self-interest rather than concern for the public welfare. It is not necessary to paint a dismal picture, but it is important to paint a realistic one. If students are to learn to think rationally, logically, and scientifically, then the teacher must be rational, logical, and scientific in his presentation.

Theodore Roosevelt once said, "The conservation of our natural resources and their proper use constitute the fundamental problem which underlies almost every other problem of our national life." Unfortunately, the formation of the policies that affect this fundamental problem are sometimes unduly influenced by strongly organized groups. Building dams is not a satisfactory way to stop floods and soil erosion; paying bounties for predators will not lead to improved hunting conditions; stocking lakes year after year does not result in better fishing; yet all of these practices are followed "in the interests of conservation" because of the insistence or pressure of organized groups.

Class discussion of local issues can help bring varying approaches to the spirit of conservation into sharp focus. A timely topic concerns the future of the Indiana Dunes on the southern shore of Lake Michigan. The governor of Indiana has favored this area as the site for a proposed inland seaport. A "Save the Dunes" movement has arisen in opposition and has attempted to have the area set aside as a national park. Unexpected support for the "Save the Dunes" faction has come from a senator from Illinois. The Indiana governor has, in effect, told the Illinois senator to keep in his own back yard. Apparently the governor feels that the senator's interest is economic rather than esthetic, since if a national park is established the potential business boom will shift to Illinois. Similar local issues—whether to keep an area as a forest preserve or to convert it to a super highway,[2] whether to protect a swamp or to drain it for a housing development —can give the teacher a wealth of discussion-provoking material.

A sensitive feeling for conservation can develop only after students begin to be conscious of these different facets. The position of the teacher should not be to give final answers on these matters, but to suggest various alternatives and to act as a catalyst in the development of student discussions.

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[1] The classic examples of the introduction of the mongoose into Hawaii and of the starling into the U.S.A. illustrate this point vividly.

[2] The present status of the Glen Helen area at Antioch College.

A Technique for the Prevention of Errors in Arithmetic

Renato Mazzei

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Introduction: Origin of the Problem

Any teacher who has examined closely the errors committed by students in arithmetic must have been impressed by the number of responses which bear no resemblance whatever to the correct ones. In fact, some answers seem absolutely ridiculous. Such type of careless thinking was evident in a brief experiment conducted by the writer recently. Five classes of ninth and tenth grade pupils, about one hundred forty in number, were given the following example and asked to choose the correct product without computing it:

$$12.4 \times 3.5 = .434 \quad 4.34 \quad 43.4 \quad 434.$$

More than sixty per cent of the students chose 4.34 as the correct answer. This group was rigidly following a rule about marking off the proper number of places in a product, without considering the size of the numbers involved. The experiment can probably be repeated in other classrooms with quite similar results.

Such errors cannot be attributed to lack of knowledge or to misapplication of a rule, but rather to failure to analyze the situation and estimate the result.

It is the writer's belief that many of the errors committed by students in arithmetic can be avoided by the process of estimating the answer before computing it. In the comparatively simple example referred to above, even the crudest estimate would have ruled out all suggested solutions except the third one. Yet incredible though it seems, more than ninety out of one hundred forty high school students chose the wrong product. Clearly, their decisions were made without much analysis or forethought. A student who examines the situation and is intelligent about numbers realizes that a little more than 12 has been multiplied by a little more than 3, and that the product is somewhat more than 36. He realizes that the product could not possibly be as small as 4.34 or as large as 434, but that it must be 43.4.

Here, then, was a situation which suggested an immediate challenge. What can be done to improve results such as this? How can students be encouraged to develop and use what is commonly referred to as "number sense" in the regular solution of their arithmetic problems? Will estimating answers to problems before solving them result in better achievement in arithmetic? Is it possible to prevent errors in arithmetic by means of this technique? An attempt to answer these questions forms the basis of this report.

The Method and Data

An experiment comparing the gains in arithmetic achievement over a sixteen-week period by two groups of students, only one of which used the estimating process, was conducted to test the writer's hypothesis. Ninety-two ninth and tenth grade students of the North Scranton Junior High School at Scranton, Pennsylvania participated.

The experiment involved the use of matched groups, with two classes in each grade being equated on the basis of the following characteristics: I.Q., previous arithmetic achievement as measured by teachers' marks, ability in arithmetic as measured by a standardized test of achievement, and chronological age. These were the important variable factors considered operative and contributing to success in arithmetic. The instructional variables were also kept constant. All classes were taught by the writer and both groups used the same text covering the same course content at the same time. The teaching methods and instructional materials used were the same for the matched groups. In addition, the rotation technique was employed, which means interchanging the experimental and control groups halfway through the experimental period, thus adding to the balancing effect of the two groups. To avoid duplication, however, only the initial experiment is recorded.

Table 1

Summary of Statistical Data Used in Matching Two Ninth Grade Groups of 27 Pupils Each on Four Separate Factors

Factors Measured	Experimental Group	Control Group
Pre-test		
Range of scores	56–81	55–81
Mean score	66.67	66.44
Standard deviation	7.17	6.87
SE of mean	1.38	1.32
I.Q. (Otis-Beta)		
Range of scores	85–116	85–114
Mean score	102.22	101.89
Standard deviation	8.10	7.86
SE of mean	1.56	1.51
Teachers' marks		
Range of scores	66–95	65–93
Mean score	78.22	78.44
Standard deviation	7.83	7.05
SE of mean	1.50	1.36
Age in months		
Range of scores	165–191	162–191
Mean score	175.22	173.56
Standard deviation	7.14	7.29
SE of mean	1.37	1.40

The groups under study were equated as far as possible on I.Q. and achievement, and then matched with reference to marks and chronological age. Table 1 shows a summary of the statistical data used to match the two ninth grade groups on each of the four factors considered relevant to success in arithmetic.

Only the ninth grade matching summary has been included in this report. To supply that for the tenth grade would merely be repetitious and add nothing important to the results.

Needed, before experimentation could begin, was some measure of the initial attainment of the students in the trait to be influenced by the experimental variable. The groups were equated in arithmetic ability, as measured by Form F of the Stanford Advanced Arithmetic Test, which includes the work normally covered up to the tenth year in general arithmetic.

At the start of the study, the experimental groups in each grade were given a half-hour of instruction and practice in the technique of estimating answers to problems before solving them. They were informed that henceforward this was to be done under all possible conditions: in class work, in homework, in blackboard work, and in tests; and that this was to be considered a requisite part of all assignments.

The control groups were not required to make estimates as part of the problem-solving process; in fact, the technique was not even mentioned in these classes.

During the initial eight weeks of the experiment, estimates were emphasized and demanded in one class and completely ignored in the other. During this period also, a tabulation of the number and per cent of errors committed by each group on seven weekly tests was maintained. At the end of the eighth week, Form E of the Stanford Advanced Arithmetic Test was administered to both groups in order to measure any difference in achievement.

A summary of the results for grade nine after the initial eight-week period is shown in Table 2.

TABLE 2

SUMMARY OF PERFORMANCE IN ACHIEVEMENT TEST AFTER INITIAL EIGHT WEEKS OF EXPERIMENTATION

Type of Measure	Experimental Group	Control Group
Grade nine		
Range of scores	60–90	58–88
Mean score	73.67	72.78
Standard deviation	8.43	7.26
SE of mean	1.62	1.40

Some difference in achievement can be noted in Table 2. A comparison of the mean scores of the two groups before and after experimentation will show the amount of gain by each group and the net gain in achievement as a result of the experimental factor. These scores are presented in Table 3.

TABLE 3

COMPARISON OF MEAN SCORES BEFORE AND AFTER INITIAL EXPERIMENTATION

Item	Mean Score Experimental Group	Mean Score Control Group
Grade nine		
Test	73.67	72.78
Pre-test	66.67	66.44
Mean gain	7.00	6.34
Experimental diff.	.66	

Close examination of Table 3 shows that use of the estimating technique for a period of eight weeks resulted in a mean net gain of less than one score point in favor of the experimental groups in an experiment conducted at the junior high school level. Whether or not this difference is significant is a matter of question.

An additional measure of difference between the groups was sought during the experimental periods by maintaining a record of the number and percentage of errors committed by each group as a result of seven weekly teacher-made tests. A summary of this tabulation is shown in Table 4.

TABLE 4

PER CENT OF ERRORS COMMITTED BY MATCHED GROUPS ON SEVEN WEEKLY TESTS

Group	Grade	Trials	Errors	Per Cent of Error
Experimental	9	1503	196	13.0
Control	9	1523	205	13.5
Experimental	10	1218	224	18.4
Control	10	1310	254	19.4

It can be seen from Table 4 that there was some slight advantage gained by the experimental groups in a tally of errors on seven weekly tests, the greatest difference being 1.0 per cent.

Interpretation

The greatest obtained difference was less than one score point with a critical ratio of 1.30. If the samples used followed the normal distribution curve, eighty per cent of the cases would fall between the mean and 1.30 times the standard error of the difference (.60) in either direction from the mean, and twenty per cent of the cases would fall outside of these limits. This indicates that, even when the true difference is zero, it could be expected that differences as large as one point might occur entirely by chance twenty times out of one hundred in comparisons of two groups similar to those used in this study. The difference, therefore, might be readily ascribed to chance.

Summary

While the gains made by the experimental groups appear to be negligible generally, closer examination of the results showed a marked variation. The lower third of the classes achieved greater average gains than the upper third in three out of four group comparisons made. Gains by these lower groups averaged 1.91 score points over their corresponding control groups in the experiment, whereas the largest average gain by any of the total groups was .79. Since it is likely that superior students excel in ability to estimate answers, it might be inferred that superior students go through the process intuitively; and that inferior students, while lower in ability to estimate, can materially increase achievement results if they do.

This much seems certain: arithmetic instruction will become more meaningful and students will show increased understanding if emphasis is placed upon a thoughtful analysis of the relations between numbers rather than upon rule-of-thumb procedures.

SMALL SCHOOLS FIND MUCH VALUE IN SCIENCE FAIRS

Results of extensive study show that better science courses for grade and high schools have been fostered by the nation-wide science fair program.

One good example of this program is the one in Archbold, Ohio. Superintendent of Schools in Archbold, Mr. J. H. Spengler, states "Before the fairs began, Archbold High School offered only two years of math; now we have four. We used to alternate physics and chemistry; now we offer both, as well as biology, physiology, psychology and general science. Of the 110 students from this high school now in college, 32 major in science."

Much of the credit for the success of the Archbold annual science fairs is due to the enthusiasm and hard work of George Clark, high school science instructor. Under his leadership, the Archbold Science Fair has become one of the outstanding events in the community.

CASMT Progress Report

Clyde T. McCormick

President, CASMT, Illinois State Normal University, Normal, Illinois

The plans for this year were started as soon as the announcement of the new officers was made at the 1958 Convention in Indianapolis.

The Vice-President, Dr. Lynwood Wren, George Peabody College for Teachers, Nashville, Tennessee, is serving as general program chairman of the 59th Annual Convention, which will be held at the Congress Hotel, Chicago, Illinois, November 26–28, 1959. The general theme of the convention is "New Science and New Mathematics for a New Era." The emphasis will be on modern developments in science and modern mathematics. We hope to have around 1200 in attendance at the convention.

Your president has been busy, with the help of the Executive Committee, making a number of appointments to the various committees in order that the activities of the Association may be carried on for the year. The following appointments have been made:

Nominating Committee

Mr. Edward Bos, Proviso High School, Maywood, Illinois, *Chairman*
Sister Mary Evarista, Mercy High School, Chicago, Illinois
Mr. Robert Grubbs, Shortridge High School, Indianapolis, Indiana
Mr. Ralph C. Huffer, Beloit College, Beloit, Wisconsin
Mr. Bruce Westling, Pierce Jr. High School, Grosse Pointe, Michigan

This will be the second year to use the method of election of officers by mail. An evaluation of this method is being made by the Policy and Resolutions Committee.

Policy and Resolutions Committee

Term Expires in 1959

Dr. Robert A. Bullington, Northern Illinois University, DeKalb, Illinois
Marilyn Zweng, 21 Lathrop Street, Madison 5, Wisconsin

Term Expires in 1960

Louis Shrode, Oak Park and River Forest High School, Oak Park, Illinois
Dr. Cecil Read, University of Wichita, Wichita, Kansas, *Chairman*

Term Expires in 1961

Alice Hach, Racine Public Schools, Racine, Wisconsin
Aubrey G. Wood, Memorial High School, Beloit, Wisconsin

The Policy and Resolutions Committee is very busy making a study of a number of problems dealing with basic policies for the Association. These items deal with possible revision of different parts of the By-Laws, with various phases of finances of the Association, and with other areas which have an important bearing for the future of CASMT.

Dr. Reginald Porter, State University of Iowa, has been appointed Chairman of the Membership Committee. He, along with his committee of seventeen members, is at work sending letters to prospective members. He is tying his work on membership closely with that of publicity in order to bring about better coordination.

Place of Meeting Committee for 1960

Hobart Sistler, J. Sterling Morton High School and Jr. College, Cicero, Illinois, *Chairman*
David Laird, Washington Township High School, Centerville, Ohio
Arthur Reynolds, Northern High School, Detroit, Michigan

Mr. Robert Hurst, Evanston Township High School, Evanston, Illinois, has accepted the very important task of General Chairman of Local Arrangements and he is carrying out his work carefully and according to schedule. He is recommending a chairman for each of the following sub-committees on Local Arrangements: Publicity for the Convention, Facilities (or Visual Aids), Hospitality (and Reception), Luncheon, Tours, and Statistics.

Your president has tried to indicate some of the responsibilities and duties of the committee members for 1959, in so far as time permitted. However, each of the 1959 committees is writing out a detailed list or report on the responsibilities and duties of his committee, in order that each chairman and committee member in 1960, and thereafter, will have a well-defined set of responsibilities and duties when he accepts an appointment.

The major part of the time of the Board meetings is being spent on dealing with basic policies of the Association. Policies dealing with the immediate future of the Association as well as long time plans are being considered.

It is hoped that if any of our members have any reactions or comments concerning the various aspects of this progress report, that they will communicate their suggestions to the Chairman of the respective committee or to the Executive Committee of the Association. In addition to our concern regarding the basic work of the Association, let each member make every effort to increase our membership in CASMT and also publicize the Annual Convention.

Problem Department

Conducted by **Margaret F. Willerding**

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note: Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2653, 2654, 2655, 2657. *Walter R. Talbot, Jefferson City, Mo.*

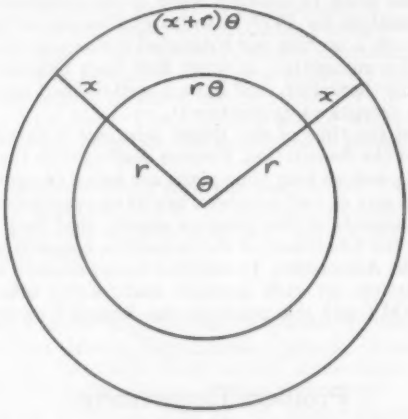
2653, 2654, 2655, 2656, 2658. *Merrill Barnebey, Tougaloo, Miss.*

2655. *J. H. Means, Austin, Texas.*

2659. *Proposed by V. C. Harris, San Diego, Calif.*

There are two concentric circular sidewalks separated by a street. A person is at a point on the outer sidewalk and wishes to get to another point on the sidewalk. Assuming that he can walk directly across the street or along the sidewalks only, should he cross or not in order to walk the least distance?

Solution by C. W. Trigg, Los Angeles City College



Let the radius of the outer edge of the inner sidewalk be r, the width of the street be x, and the central angle subtended by the smaller arc joining the two points on the inner edge of the outer sidewalk be $\theta \leq \pi$ (radians).

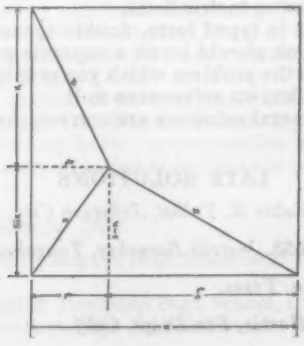
If he does not cross the street, he will travel $a=(x+r)\theta$. If he does cross the street at once and recrosses at the last possible moment, he will travel $b=2x+r\theta$. Then $a \gtrless b$ according as $(x+r)\theta \gtrless 2x+r\theta$, or $\theta \gtrless 2$. Hence, to walk the least distance, he should not cross if $\theta<2$; he should cross if $\pi \geqq \theta>2$; and if $\theta=2$ it does not matter.

Solutions were also offered by Donald Byrkit, West Chicago, Ill.; Phillip Fung, Pocatello, Idaho; and W. R. Talbot, Jefferson City, Mo.

2660. *Proposed by Ben L. Swensen of Austin, Texas.*

Find the area of the square, three corners of which are 3, 4, and 5 rods distant respectively from a point within the square.

Solution by Brother James Dowdy of St. Louis, Mo.



From the drawing, we form the following equations:

$$(s-y)^2+(s-x)^2=25 \tag{1}$$

$$x^2+y^2=16 \tag{2}$$

$$(s-x)^2+y^2=9. \tag{3}$$

From (1) and (3), by elimination we have:

$$(s-y)^2-y^2=16. \tag{4}$$

From (2) we have:

$$x=\sqrt{16-y^2}.$$

Substituting in (3) we obtain:

$$(s-\sqrt{16-y^2})^2+y^2=9. \tag{5}$$

From (4), by multiplying and collecting terms we have:

$$s^2-2sy=16. \tag{6}$$

From (5), by multiplying and collecting terms we get:

$$64s^2-4s^2y^2=49+14s^2+s^4. \tag{7}$$

From (6), by solving for y and squaring we obtain:

$$y^2=\frac{s^4-32s^2+256}{4s^2}.$$

Substituting this in (7):

$$64s^2-4s^2\left(\frac{s^4-32s^2+256}{4s^2}\right)=49+14s^2+s^4.$$

Since the area of a square is equal to s^2, we let $A=s^2$. Then we have:

$$64A-A^2+32A-256=49+14A+A^2$$

$$2A^2-82A+305=0$$

$$A=\frac{82\pm\sqrt{4284}}{4}=\frac{41\pm\sqrt{1071}}{2}=36.87 \text{ square rods (approximately) using the positive value for the radical. The negative value gives us an answer that is not feasible.}$$

Solutions were also offered by Robert A. Atkins, Brooklyn, N. Y.; Merrill Barnebey, Tougaloo, Miss.; Phillip Fung, Pocatello, Idaho; Benjamin Greenberg, Fort Hamilton High School; William W. Johnson, Cleveland, Ohio; C. N. Mills, Sioux Falls College, S. D.; Brother Norbert, Chicago, Ill.; Albert J. Read, Oneonta, N. Y.; Walter R. Talbot, Jefferson City, Mo.; C. W. Trigg, Los Angeles, Calif.; Philip Wahl, Hicksville, Ohio; Floyd Wilder, Bethany, Okla.; Dale Woods, Pocatello, Idaho; and the proposer.

EDITOR'S NOTE: C. W. Trigg, Los Angeles Calif., states that other problems dealing with the basic configuration of this problem may be found in:

SCHOOL SCIENCE AND MATHEMATICS, Vol. 15, 632, (1915); Vol. 32, 788, (1933); Vol. 46, 89, 783, (1946); Vol. 50, 324, (1950).

National Mathematics Magazine, Vol. 12, 141, (1937); Vol. 16, 106, (1941); Vol. 17, 39, (1942).

American Mathematical Monthly, Vol. 3, 155, (1896); Vol. 35, 94, 383, (1928); Vol. 47, 396, (1940); Vol. 50, 392, (1943).

2661. *Proposed by Alna Zame, Coral Gables, Fla.*

What is the next term in the series

$$1\ 3\ 4\ 7\ 6\ 12\ 8\ 15\ 13\ 18\ 12\ 28\ 14\ 24\ 24 \cdots ?$$

Solution by Cecil B. Read, University of Wichita, Wichita, Kan.

It is possible to give any specified number and it can be the next term in the series proposed in the problem. There are given 15 values. If we ask for a polynomial of degree 15, it is always possible to make this polynomial satisfy 16 conditions: i.e.

$$f(1)=1,\quad f(2)=3,\quad f(3)=4 \cdots f(14)=24,\quad f(15)=24$$

and finally

$$f(16)=n$$

where n is any given number.

Problems of this type often occur on psychological examinations where one is asked to name the next one, two, or possibly three terms in the series. It is not often realized that one could write any three numbers and a sequence could be found for which these numbers are correct. Hence, the problem as stated is meaningless.

2662. *Proposed by Brother Felix John, Philadelphia, Pa.*

If the 6th, 7th, and 8th terms of $(x+y)^n$ are respectively 112, 7 and $\frac{1}{4}$, find x, y, and n.

Solution by Walter R. Talbot, Jefferson City, Mo.

The 6th, 7th, and 8th terms respectively are

(1) $$C(n, 5)x^{n-5}y^5=112$$

(2) $$C(n, 6)x^{n-6}y^6=7$$

(3) $$C(n, 7)x^{n-7}y^7=\tfrac{1}{4}$$

Dividing (1) by (2) and (2) by (3) gives respectively

(4) $$\frac{6x}{(n-5)y}=16 \qquad (5) \qquad \frac{x}{(n-6)y}=4.$$

Dividing (4) by (5) gives $6(n-6)=4(n-5)$ from which $n=8$.
Then in (5) $x=8y$ and in (1) $C(8, 5)\cdot(8y)^3y^5=112$ from which

$$8^3y^8=2 \quad \text{or} \quad y=\tfrac{1}{2}.$$

Then $n=8$, $y=\frac{1}{2}$, and $x=4$.

Solutions were also offered by Donald Byrkit, West Chicago, Ill.; Joseph Dence, Toledo, Ohio; J. Byers King, Denton, Md.; John Q. Taylor King, Austin, Texas; H. R. Leifer, Pittsburgh, Pa.; C. N. Mills, Sioux Falls College, S. D.; Brother Norbert, Chicago, Ill.; J. P. Phillips, Louisville, Ky.; Paul Tomljanovic, Tucson, Ariz.; C. W. Trigg, Los Angeles, Calif.; Dale Woods, Pocatello, Idaho; and the proposer.

2663. *Proposed by Alan Wayne, Baldwin, N. Y.*

Find the digits represented uniquely by the letters in the addition

$$\begin{array}{r} \Theta NCE \\ C\Theta DED \\ \hline DIGITS \end{array}$$

Solution by C. W. Trigg, Los Angeles City College

Since the sum of two digits cannot exceed 18, we have immediately that $D=1$, $C=9$, and $I=0$. (To avoid confusion with zero, the letter O is replaced by Θ.) Then proceeding from the right, the several columnar additions determine the relationships:

$$E+1=S.$$
$$9+E=T+10, \quad \text{so} \quad E-1=T.$$
$$N+1+1=10, \quad \text{so} \quad N=8.$$
$$\Theta+\Theta+1=G+10, \quad \text{so} \quad G+9=2\Theta,$$

hence G is odd. Then either $G=3$, $\Theta=6$ or $G=5$, $\Theta=7$. But the first two equations establish T, E, S as consecutive digits. Thus $T=2$, $E=3$, $S=4$, $G=5$, $\Theta=7$, and no letter represents 6. The reconstructed addition is

$$7893+97131=105024.$$

In any system of numeration with base r, we would have $D=1$, $C=r-1$, $I=0$, $N=r-2$, consecutive digits T, E, S, and $G+r-1=2\Theta$. When $r=9$ there are no solutions, when $r=11$ there are three solutions, and when $r=12$ there are 5 solutions. The number of solutions increases with r, so the decimal scale is the only one in which the representations are unique. The solutions for $r=11$ are:

0	1	2	3	4	5	6	7	8	9	X
I	D	G	T	E	S	Θ	—	—	N	C
I	D	T	E	S	—	G	—	Θ	N	C
I	D	—	T	E	S	G	—	Θ	N	C

Solutions were also offered by Robert A. Atkins, Brooklyn, N. Y.; Donald Byrkit, West Chicago, Ill.; Benjamin Greenberg, Fort Hamilton High School; J. Byers King, Denton, Md.; John Q. Taylor King, Austin, Texas; H. R. Leifer, Pittsburgh, Pa.; J. H. Means, Austin, Texas; Brother Norbert, Chicago, Ill.; J. P. Phillips, Louisville, Ky.; Walter R. Talbot, Jefferson City, Mo.; James E. Ward, Denton, Md.; Floyd Williams, Jefferson City, Mo.; and Dale Woods, Pocatello, Idaho.

2664. No solution has been offered.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

2654, 2660, 2662, 2663. *Lee H. Mitchell, New Trier High School, Winnetka, Ill.*

2660. *Jules Labuzan, Sunnyside High School, Tucson, Ariz.*

2662. *David Binnie, Warren Central High School, Indianapolis, Ind.*

2663. *Walter Griffin, Allan Reddish, Steve Svatik, Howard Thompson, Ernest York, all of Caroline High School, Denton, Md.*

2663. *Jeannie Bloom, St. Agnes College, Baltimore, Md.*

2663. *Douglas Doeden, William Hirzel, Jo Ann Hurni, Robert Poth, Tom Ridenour, all of Hicksville High School, Hicksville, Ohio.*

2663. *John F. Osinski, Jr., State Teachers College, Salisburg, Md.*

2663. *David Milne, Crawford High School, San Diego, Calif.*

2663. *David Bock, Mt. Lebanon High School, Pittsburgh, Pa.*

2663. *David Paschal, Loose Creek, Mo.*

2663. *Daniel Woods, Roger Couvion, both of McBride High School, St. Louis, Mo.*

2663. *Linda Gibbon, Manuel Elkourie, Julianna Rohling, Marian Spina, Tippy Tipton, Bernice Reymann, Brooks Carter, Jr., William E. McDermott, John Mackinaw, Joan Palmer, Elizabeth Mielsen, Paul Ozburn, Joe Monti, Hugh Taylor, Joe Hagerty, all of John Carroll High School, Birmingham, Ala.*

2663. *Anthony T. Tumolo, Enid Oppenheimer, Cari Soden, Ruth Applebaum, all of Fort Hamilton High School, Brooklyn, N. Y.*

2663. *J. Corra, J. Helwig, J. Minecci, W. J. Vaudreuil, LaSalle College High School, Philadelphia, Pa.*

EDITOR'S NOTE: THE EDITOR OF THIS PROBLEM DEPARTMENT IS AGAIN IN NEED OF SOME GOOD PROBLEMS. PLEASE SEND ANY NEW OR INTERESTING PROBLEMS TO YOUR EDITOR.

PROBLEMS FOR SOLUTION

2683. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kans.*

For every integer n greater than unity, prove that

$$1/1+1/2+\cdots+1/n<\sqrt{2n-1}.$$

2684. *Proposed by J. B. Love, St. Davids, Pa.*

Given any triangle with angles A, B, and C, and with opposite sides a, b, c Show that

$$\pi/3\leq\frac{aA+bB+cC}{abc}\leq\pi/2.$$

2685. *Proposed by C. W. Trigg, Los Angeles, Calif.*

Show how to dissect a non-equilateral triangle by straight cuts into three pieces which can be arranged to form two triangles similar to the given triangle.

2685. *Proposed by Brother Felix John, Philadelphia, Pa.*

Show that every prime factor is contained in $(n+r)!$ as often at least as it is contained in $n!r!$.

2687. *Proposed by John Satterly, Toronto, Canada.*

Prove if four circles are mutually tangential

$$(\sum 1/r)^2=2\sum d^2.$$

2688. *Proposed by Donald Byrkit, West Chicago, Ill.*

Determine the radius of the circumscribed circle of the triangle whose sides are consecutive integers if the radius of the inscribed circle is $\sqrt{3}$.

Books and Teaching Aids Received

FUNDAMENTALS OF NUCLEAR ENERGY AND POWER REACTORS, by Henry Jacobowitz. Paper. 118 pages. 15×23 cm. 1959. John F. Rider Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $2.95.

FUNDAMENTALS OF RADIO TELEMETRY, by Marvin Tepper. Paper. Pp. viii+116. 15×23 cm. 1959. John F. Rider Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $2.95.

ISLAND IN THE DESERT, The Challenge of the Nile, By Charles R. Joy. Cloth. 95 pages. 14×21 cm. 1959. Coward-McCann, Inc., 210 Madison Ave., New York, N. Y. Price $2.50.

VOLCANOES AND GLACIERS, The Challenge of Iceland, by Sturges F. Cary. Cloth. 95 pages. 14×21 cm. Coward-McCann, Inc., 210 Madison Ave., New York, N. Y. Price $2.50.

CHANGING FACE OF NORTH AMERICA, The Challenge of the St. Lawrence Seaway. By Patricia Lauber. Cloth. 96 pages. 14×21 cm. 1959. Coward-McCann, Inc., 210 Madison Ave., New York, N. Y. Price $2.50.

OUR EARTH, by Arthur Beiser. Cloth. 123 pages. 13×20 cm. 1959. E. P. Dutton and Co., 300 4th Avenue, New York 10, N. Y. Price $2.95.

MEN AT WORK ON THE WEST COAST, by Henry B. Lent. Cloth. 128 pages. 15×21.5 cm. 1959. G. P. Putnam's Sons. 210 Madison Avenue, New York, Price $3.00.

THE SCIENTIFIC REVOLUTION, Challenge and Promise, Edited by Gerald W. Elbers and Paul Duncan. Cloth. Pp. viii+280. 15×23 cm. 1959. Public Affairs Press, 419 New Jersey Avenue, S.E., Washington 3, D. C. Price $6.00.

LIFE GOES ON, Second Edition, by R. Will Burnett, Jessie Williams Clemensen, and Howard S. Hoyman. Paper. 56 pages. 16×23 cm. 1959. Harcourt, Brace and Co., 750 3rd Ave., New York 17, N. Y.

ENROLLMENTS, TEACHERS, AND SCHOOLHOUSING, In full-time Public Elementary and Secondary Day Schools, by Samuel Schloss and Carol Joy Hobson. Paper. Pp. vi+18. 20×26 cm. 1959. U. S. Department of Health, Education and Welfare, Office of Education, Washington, D. C. Price $.20.

VOCATIONAL AND PROFESSIONAL MONOGRAPHS:
PETROLEUM ENGINEERING, by C. V. Kirkpatrick, 24 pages
ENGINEERING, by Edward H. Robie, 36 pages
BEAUTY CULTURE, by Miriam L. Sinclair, 16 pages
CAREERS IN THE ATOMIC ENERGY INDUSTRY, by Hold L. Walker, 32 pages
All: paper. 15×23 cm. 1959. Bellman Publishing Co., Cambridge 38, Mass. Price $1.00 ea.

TEACHING SCIENCE THROUGH HOLIDAYS AND SEASONS, by Matthew F. Vessel and Herbert H. Wong. Paper. 36 pages. 17×24 cm. 1959. Fearon Publisher, 2263 Union St., San Francisco, Calif. Price $1.50.

STAR '58 ABSTRACTS, Edited by Abraham Raskin. Paper. Pp. iv+44. 15×23 cm. 1959. National Science Teachers Association, 1201 16th St., N.W., Washington, D. C. Price $1.00.

MAN AND SCIENCE, by Ben Day Smith. Cloth. 126 pages. 13.5×20.5 cm. 1959. Exposition Press, 386 4th Ave., New York 16, N. Y. Price $3.00.

ELEMENTARY SCIENCE SERIES:
SCIENCE FOR WORK AND PLAY, Book 1, 154 pages, $2.20.

SCIENCE FOR HERE AND NOW, Book 2, 213 pages, $2.44.
SCIENCE FAR AND NEAR, Book 3, 279 pages, $2.68.
SCIENCE IN YOUR LIFE, Book 4, 314 pages, $2.80.
SCIENCE IN OUR WORK, Book 5, 346 pages, $2.92.
SCIENCE FOR TOMORROW, Book 6, 378 pages, $3.08.
All: Cloth. 16×22 cm. 1959, by Herman and Nina Schneider. D. C. Heath Co., 285 Columbus Avenue, Boston 16, Mass.

RADIOACTIVITY MEASURING INSTRUMENTS, by M. C. Nokes. Cloth. Pp. viii+75. 13.5×21.5 cm. 1958. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. Price $4.75.

CHILDREN WITH SPEECH AND HEARING IMPAIRMENT, by Wendell Johnson. Paper. Pp. vi+32. 15×23 cm. 1959. U. S. Office of Health, Education and Welfare, Office of Education, Washington, D. C. Price $.20.

INTRODUCTION TO ZOOLOGY, by H. W. Manter and D. D. Miller, *The University of Nebraska*. Cloth. Pp. x+689. 16.5×23.5 cm. 1959. Harper and Brothers, 49 E. 33rd St., New York 16, N. Y. Price $7.50.

GUIDE TO THE NATIONAL DEFENSE EDUCATION ACT OF 1958, by Theodora E. Carlson and Catherine P. Williams. Paper. Pp. iii+32. 20×26 cm. 1959. U. S. Department of Health, Education and Welfare, Office of Education, Washington, D. C. Price $.30.

BUILDING THE AMATEUR RADIO STATION, by Julius Berens. Paper. Pp. vii+128. 14×21.5 cm. 1959. John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y. Price $2.95.

THE VERTEBRATE STORY, by Alfred Sherwood Romer, *Harvard University*. Cloth. Pp. vii+437. 17×23 cm. 1959. The University of Chicago Press, 5750 Ellis Ave., Chicago 37, Ill. Price $7.00.

NEW DYNAMIC BIOLOGY, by Arthur O. Baker, Lewis H. Mills, and Julius Tanczos, Jr., all of *Cleveland, Ohio Public Schools*. Cloth. Pp. xiii+616. 18×22 cm. 1959. Rand, McNally Co., P.O. Box 7600, Chicago, Ill.

INSTRUCTION TESTS to accompany NEW DYNAMIC BIOLOGY, by Marsdon U. Grubb. Paper. 64 pages. 20×26 cm. 1959. Rand, McNally Co., P.O. Box 7600, Chicago, Ill.

GENERAL SCIENCE TODAY, by Phil R. Gilman and L. F. Van Houten. Cloth. Pp. x+630. 15.5×22 cm. 1957. Rand, McNally Co., P.O. Box 7600, Chicago, Ill.

ROSWELL-CHALL DIAGNOSTIC READING TEST OF WORD ANALYSIS SKILLS, by Florence G. Roswell and Jeanne S. Chall, *The City College, New York*. Paper. 4 pages. 14×21.5 cm. 1959. Essay Press, Box 5, Planetarium Station, New York 24, N. Y. Price $2.50 per package of 35 tests with manual, plus postage.

The following teacher-written materials are available from:

Union Springs Central School
Central School District No. 1
Union Springs, N. Y.

THE SCIENCE WORKSHOP. A list of equipment needed for a good science workshop.

FRANKLY, WE WOULD LIKE YOUR OPINION. A student survey sheet which would help a teacher evaluate attitudes and opinions of a given course.

SCIENCE PROJECTS. Some basic ideas for a science teacher to consider for either short-term or long-term project work.

NUCLEAR ACTIVITY. A unit plan for nuclear science suitable for 9th grade as well as a good basis for Chemistry or Physics students.

HOW TO STUDY. A group of ideas which aid in the teaching of study skills and techniques . . . for both the teacher and the student. A special exercise sheet is attached.

REVISION OF FIRST PORTION OF PRELIMINARY EDITION OF LABORATORY GUIDE No. 2, Physical Science Study Committee. Paper. 21.5×28 cm. August 29, 1958. Physical Science Study Committee, 164 Main St., Watertown 72, Mass.

REVISION OF SECOND PORTION OF PRELIMINARY EDITION OF LABORATORY GUIDE No. 2, Physical Science Study Committee. Paper. 21.5×28 cm. September 25, 1958. Physical Science Study Committee, 164 Main St., Watertown 72, Mass.

ARITHMETIC IN MY WORLD, Book 9, by C. Newton Stokes, Anne Beattie, Ruth I. Hoffman. Cloth. 480 pages. 17×21 cm. 1959. Allyn and Bacon, Inc., Boston, Mass.

TEACHERS' EDITION for ARITHMETIC IN MY WORLD, Book 9, by C. Newton Stokes, Anne Beattie, Ruth I. Hoffman. Cloth. Pp. iv+308. 21×28 cm. 1959. Allyn and Bacon, Inc., Boston, Mass.

Book Reviews

LANGUAGE, THOUGHT AND THE HUMAN MIND, by Chester A. Lawson. Cloth Pp. vi+117. 14×20.5 cm. 1958. Michigan State University Press, E. Lansing Mich. Price $4.50.

Dr. Lawson has performed a valuable service in pointing out the basic similarity of all problem-solving activity by the human mind, whether this be in relation to a scientific situation, or a religious, socio-political or educational one. All such activity necessarily begins with some kind of "unsatisfactory" state. This state is based on disquieting experience or unexplained data. In the light of all available experience or data, however, one or more possible solutions may appear to be available. The trying out of these, one at a time, beginning with the one whose success seems most likely, is the way by which we arrive at workable problem-solutions. It makes no difference what is the framework within which the problem arises. The method of attack is always basically the same.

This relatively simple process of problem-solving is capable of being described in various ways. Its description by use of the ordinary symbols of language constitutes the most common of these ways. Based upon this kind of description, however, it is possible to superimpose other types of "shorthand" description, through the use of diagrams, or by the setting up of relationships between the units of symbolic logic. Dr. Lawson has set forth such a system for describing problem-solving operations, and on the basis of this, he has proposed a tentative Explanation of the operation of the human mind as a functioning mechanism.

It should be mentioned that this system was developed, at least in part, as a result of attempting to solve the problem of building an integrated natural science course at the general education level. Evidence of its successful application is the fact that the study of taxonomic and deductive systems in science now constitutes the basis upon which the integration of biological and physical science materials is accomplished. The course involves detailed studies of major conceptual schemes within the sciences, their origin, their basis in observed data, and their operation as a foundation for constructing hypotheses and predicting probable consequences.

W. C. VAN DEVENTER
Western Michigan University

FUNDAMENTALS OF RADIO TELEMETRY, by Marvin Tepper. Paper. Pp. vi+116. 23×15.5 cm. 1959. John F. Rider Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price, $2.95.

Fundamentals of Radio Telemetry is a book intended to present a general overall picture of the area. No attempt is made to present engineering aspects or minute details regarding telemetry. A basic knowledge of electronics is all that is necessary for an understanding of the text.

The book contains 8 chapters: Introduction to Telemetry; Telemetry Inside the Missile; Multiplexing; The Telemetry Receiving Station; Recovering and Recording the Data; Digital Techniques in Telemetry; Telemetry Data Reduction; and Satellite Telemetry. In addition, there is Appendix I—Telemetry Standards for Guided Missiles, and Appendix II—Magnetic Recorder/Reproducer Standards.

The book is well illustrated with photographs and drawings to aid the reader in understanding topics generally considered to be complicated.

It is the opinion of this reviewer that this book should be read by anyone interested in a general, non-technical treatment of telemetry.

J. BRYCE LOCKWOOD
Highland Park Junior College
Highland Park, Mich.

MATHEMATICS IN DAILY USE, Third Edition, by Walter W. Hart, Veryl Schult, and Lee Irvin. Cloth. Pp. ix+374+43. 16×23.5 cm. 1958. D. C. Heath and Co., Boston, Mass. Price $3.20.

Mathematics in Daily Use is a general mathematics textbook designed for students who are taking a terminal course in mathematics. Although topics from arithmetic, geometry and algebra are included, the emphasis is placed on mathematics used in daily life and the arithmetical processes needed to solve them.

Since most classes in general mathematics contain students who vary in ability, an attempt has been made to provide materials for all levels of ability and interest. Chapers 1 through 6 include simple materials for developing the basic principles and skills in arithmetic. The materials are presented in greater detail than is usually found in textbooks for earlier grades. All the basic concepts, vocabulary and skill-producing practice appear in each chapter.

Chapters 7 through 9 include problems requiring miscellaneous processes for the purpose of further development of the skills and concepts presented in earlier chapters. Emphasis is placed on problems that arise in daily affairs of the average individual. Adequate materials are presented so that the teacher may select topics appropriate for the class. These selections may be made from some or all the chapters without seriously disrupting the general organization of the textbook.

Chapters 10 and 11 are designed to stimulate the student to further study in mathematics. These chapters are intended to serve as an introduction to algebra and geometry. No attempt is made to develop skill in these areas.

It is the opinion of this reviewer that this textbook is adequate for the type of course for which it is intended. The students should find it interesting and should be stimulated to improve their mathematical ability.

J. BRYCE LOCKWOOD

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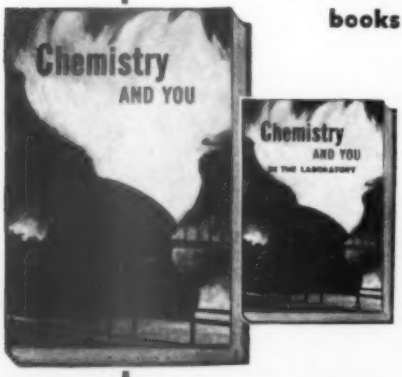

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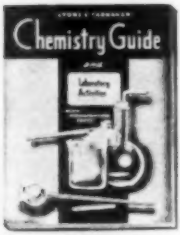

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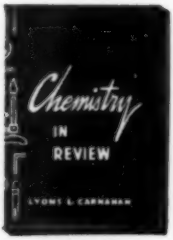

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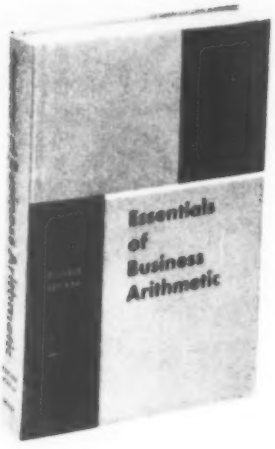

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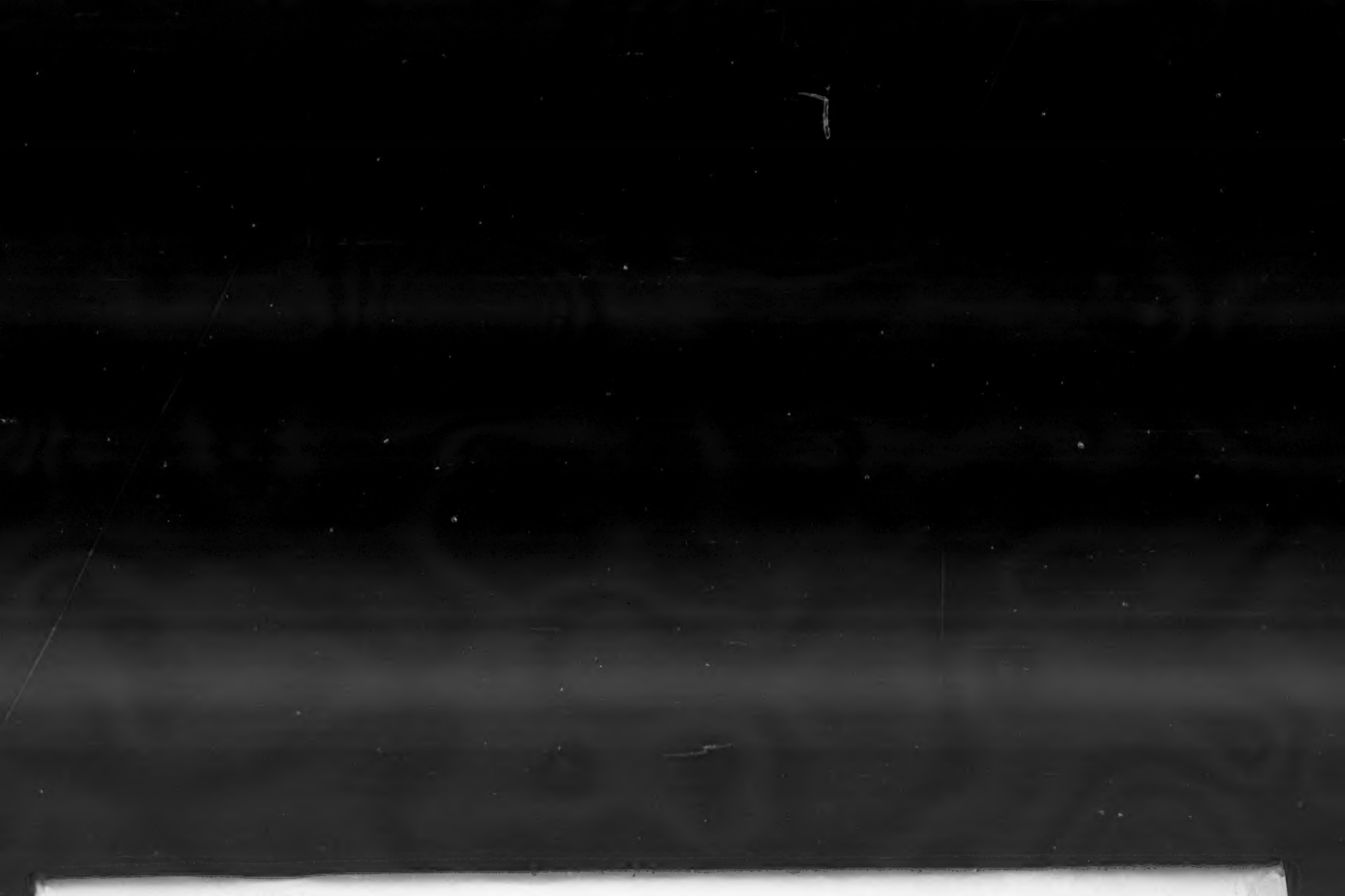
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